Mississippi State UNIVERSITY

Center for Air Sea Technology

FY93 AND FY94 RESEARCH PROGRAM IN NAVY OCEAN MODELING AND PREDICTION

Technical Report 94-3

30 September 1994

Prepared for: Office of Naval Research (Code 1242)
Under Research Grant N00014-92-J-4109

Mississippi State University Center for Air Sea Technology
Stennis Space Center, MS 39529-6000

TECHNICAL REPORT 94-3

MISSISSIPPI STATE UNIVERSITY
CENTER FOR AIR SEA TECHNOLOGY
FY93 and FY94 RESEARCH PROGRAM IN
NAVY OCEAN MODELING AND PREDICTION

by

Lanny A. Yeske[1] and James H. Corbin[2]

[1]Senior Research Scientist, Mississippi State University Center for Air Sea Technology, Stennis Space Center, MS 39529-6000

[2]Director, Mississippi State University Center for Air Sea Technology, Stennis Space Center, MS 39529-6000

30 September 1994

This research was supported by the Department of the Navy, Office of the Chief of Naval Research under Research Grant N00014-92-J-4109 with Mississippi State University. The opinions, findings, conclusions, and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the U.S. Government. No official endorsement should be inferred.

ABSTRACT

The Mississippi State University Center for Air Sea Technology (CAST) began operation on 1 October 1992 under a two-year Research Grant (N00014-92-J-4109) issued by the Office of Navy Research in support of the Navy Ocean Modeling and Prediction Program.

This final technical/performance report is submitted in accordance with requirements contained in the Research Grant. Included herein is a discussion of the FY93 (1 October 1992-30 September 1993) research program under the Experimental Center for Mesoscale Ocean Prediction Project with its three tasks of Ocean Model Initialization and Evaluation Data; Ocean Model Verification, Evaluation, and Transition; and Scientific Visualization for Model Evaluation. This is followed by the FY94 (1 October 1993-30 September 1994) program which was reorganized into three projects corresponding to 6.1 basic research, 6.2 exploratory development, and 6.3 advanced development research, which were respectively, the Coastal and Semi-Enclosed Seas Relocatable Models Project, the Ocean Model Technology Project, and the Advanced Development and Transitions Project.

Also included in this final report is a discussion of the planned research for FY95 and FY96. This is followed by Appendix I which summarizes eight other contracts obtained by CAST during this period. These contracts with the Naval Research Laboratory, Naval Oceanographic Office, Advanced Research Projects Agency, Army Corps of Engineers Coastal Engineering Research Center, Department of Defense, Office of Naval Research, and Gulf Weather Corporation significantly leveraged the research conducted under this grant. Finally, Appendix II summarizes the CAST publications completed during this two year period as well as CAST involvement in scientific and technical presentations and demonstrations; CAST sponsored seminars, workshops, and meetings; professional recognition and awards to CAST personnel; interdisciplinary activities; workshops and meetings attended by CAST personnel; proposals submitted; and contracts awarded.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

1.0 INTRODUCTION

The Mississippi State University (MSU) Center for Air Sea Technology (CAST) evolved from the Institute for Naval Oceanography's (INO) Experimental Center for Mesoscale Ocean Prediction (ECMOP) which was started in 1989.

On 17 July 1992, with INO scheduled to be disestablished on 1 October 1992, the MSU Vice President for Research submitted an unsolicited proposal to ONR that ECMOP be merged with the organizational structure of MSU. This proposal was developed to assure that the Navy mission relevancy of ECMOP remained intact. Equally important was that the reorganization of ECMOP within MSU provided excellent opportunities for program enhancement and diversification, not only within the Navy, but with other federal, state, and private organizations. Under this proposal, the fundamental ECMOP objectives continued to be:

- Support the technical requirements of ocean modeling efforts by providing routine day-to-day technical support to the scientific staff, and by designing, developing, and implementing next generation technical support capability to enhance the researcher's ability to develop, validate, evaluate, and transition ocean models; and

- Tailor and transition applicable advanced technical support capabilities developed for the research community to the operational Navy, and to expedite the transition process by having similar and compatible data management, evaluation criteria, and hardware and software operating environments in both communities.

This proposal was subsequently endorsed by ONR and a two-year Research Grant (N00014-92-J-4109) was issued on 29 September 1992. The newly formed MSU Center for Air Sea Technology, which would be responsible for the proposed research, began operation on 1 October 1992 with 14 personnel.

This final technical report is submitted in accordance with requirements contained in this Research Grant. In Section 2.0 we discuss the FY93 (1 October 1992-30 September 1993) research program, whereas Section 3.0 presents the FY94 (1 October 1993-30 September 1994) program. The planned research for FY95 and FY96 is discussed briefly in Section 4.0. These sections are followed by Appendix I which presents summaries of eight other contracts obtained by MSU CAST during this period that leveraged the research accomplished under this Grant. These contracts included those with the Naval Research Laboratory, Naval Oceanographic Office, Advanced Research Projects Agency, Army Corps of Engineers Coastal Engineering Research Center, Department of Defense, Office of Naval Research, and Gulf Weather Corporation. Finally, Appendix II summarizes

for this two year period CAST publications; presentations and demonstrations; sponsored seminars; sponsored workshops and meetings; professional recognition and awards; interdisciplinary activities; workshops and meetings attended; and submitted proposals/contracts awarded.

2.0 FY93 RESEARCH PROGRAM

The emphasis of the research continued to be on a modularized software system that integrates the functions of data management, graphics and visualization routines, and objective evaluation for purposes of ocean model development, validation, evaluation, and transition. All were built upon a state-of-the-art data base management system (DBMS).

The ECMOP plans and milestones supported ocean model prediction/evaluation and were grouped under three major tasks described as:

- ECMOP Project (6.1, 6.2, 6.3, and 6.6 Components)
  - Task 1: Ocean Model Initialization and Evaluation Data (6.1, 6.2, and 6.6)
  - Task 2: Ocean Model Verification, Evaluation, and Transition (6.1, 6.2, and 6.3)
  - Task 3: Scientific Visualization for Model Evaluation (6.1 and 6.2)

The prescribed funding for ECMOP in FY93 of $1,384K was distributed as follows:

	$(K)			
	6.1	6.2	6.3	6.6
-Task 1	237	200		125
-Task 2	145	119	200	
-Task 3	230	128		

With the exception of the 6.3 transition effort, the majority of the milestones within each task were in support of the DAMEE modeling efforts of the University of Southern Mississippi (USM), which formerly had been INO's North Atlantic Ocean Prediction Systems Project. All three tasks were closely coupled. The basic research efforts fed the exploratory and advanced developmental research

efforts, which in turn fed the transition efforts to the operational Navy. The ECMOP Project was vertically and horizontally integrated.

It should be noted that all the applications developed within ECMOP interfaced to the Navy Environmental Operational Nowcast System (NEONS) developed at NRL Monterey. The NEONS had been accepted for use on POPS facilities. Therefore, any applications developed within ECMOP were immediately compatible with the Navy's Primary Ocean Prediction System (POPS) Cray Y-MP, with only minimal modifications required for specific system configurations. The NEONS had also been accepted by non-Navy users such as the National Climate Data Center, and the Canadian and Australian Meteorological services.

2.1 Ocean Model Initialization and Evaluation Data Task

This task had as an objective to work with USM principal investigators in their modeling projects to identify their data requirements, and then to acquire and ingest the data into the DBMS. A second objective was to continue consolidating existing data sets, and to collect and archive real-time data sets from Navy operational centers for model forcing, initialization, and evaluation. This was important to the Navy ocean modeling community as a whole, in-house scientists, and university researchers alike. A single integrated DBMS with common quality control procedures would consolidate, streamline, and eliminate duplication of individual project archives, as well as provide both historical and real-time operational products to the researcher. This objective was delayed because the high speed data exchange line (T1) between FNMOC and NAVOCEANO did not become operational until near the end of FY92.

A mid-range MSU objective was to work with the USM modeling projects to specify the requirements for model verification data sets and to develop an implementation plan to meet transition requirements. A longer range objective was to compile a global ocean system verification data set. In preparation for this, MSU planned to host a Data Working Group in FY93 in preparation for a major Ocean Prediction Workshop (OPW) in FY94.

The ECMOP Modular System (EMS) and the Interactive Data Editing and Analysis System (IDEAS) prototypes were transitioned to NAVOCEANO and FNMOC during FY92. User feedback indicated fruitful areas for enhancements and development to both systems. One 6.2 objective was to work with NAVOCEANO to design an artificial intelligence/expert system (AI/ES) interface to the DBMS. A related 6.6 task involved enhancements to the NEONS interface to the DBMS to add new data types.

The major MSU focus under the data task was to work with USM principal investigators in a phased approach under DAMEE, the effort would be centered in the North Atlantic Basin, and in the Mediterranean for the Coastal/Semi-Enclosed Seas. The period of the GEOSAT Exact Repeat Mission from November 1986 through December 1989 would be used for the basin modeling effort. We also wanted to work with data from TOPEX/Poseidon and/or ERS-1 to collect, analyze, quality control, edit, and correct orbit errors, and to produce global research quality data sets.

This task involved a cooperative MSU, USM, NRL Stennis, and NRL Monterey effort to establish a jointly used data base. The work included establishing data management procedures, identifying specific data sets to ingest into the DBMS, and identifying data related applications. Consolidated data sets of the forcing fields needed to support modeling efforts (NOGAPS/NORAPS wind/stress and heat flux, OTIS and TOPS fields, etc.) were incorporated into ECMOP.

The foundation of ECMOP was a state-of-the-art relational DBMS coupled with NEONS, a sophisticated data model that acts as an interface between the user developed applications and the DBMS. CAST worked with NRL Monterey to enhance NEONS, to build applications, and to advocate its use throughout the community. An innovative research area for FY93 involved working with NAVOCEANO to develop the design for an AI/ES interface to the DBMS. The interface monitored a satellite analyst's work to identify ocean features in an infrared image. Then, based on rules and activation by the analyst, it queried the DBMS for collaborating information from previous analyses, bring that back to the analyst for consideration, and allow the analyst to add his current analysis to the DBMS. A related effort investigated the feasibility of using automated, statistical routines to develop an online "living atlas" (dynamic climatology) of the features that would be updated each time a new analysis is performed. This effort was collaborative with Tulane University.

The FY93 major completions and accomplishments included:

- Acquiring and ingesting into the DBMS data sets to support NOMP modeling projects;
- Hosting a working group to consider a design, inventory, and implementation plan for a global ocean model verification data set;
- Fully implementing an online data browser to the DBMS;

- Upgrading NEONS for line type data and design considerations for acoustic data types for Mediterranean;

- Working with NAVOCEANO to design an AI/ES interface to the NEONS/DBMS; and

- Implementing the DBMS in a distributed environment and on the NAVOCEANO POPS.

2.2 Ocean Model Verification, Evaluation, and Transition Task

This task focused on the evaluation and verification support to the USM DAMEE basin and coastal projects, as well as supporting the conclusion of DAMEE-GSR. This involved implementing new verification and evaluation schemes, and incorporating them into the EMS.

Based on the results of DAMEE-GSR, several objective routines for error analysis, applicable to the operational community, were added to the verification module of the EMS and transitioned. Also, the results of investigations into objective feature identification routines, as well as spectral decomposition routines, were also incorporated for transition. Another transition involved refining the watermass analysis capability of IDEAS by tailoring it respectively for NAVOCEANO and FNMOC applications. The FNMOC portion incorporated preset classification limits that allowed the process to be automated and included in their operational system. The task for NAVOCEANO developed routines to aid an analyst in building synthetic profiles and extending profiles to the bottom. A new research area was the application of AI/ES techniques to data base construction and feature identification in both model output and infrared imagery. This was a feasibility study done in collaboration with operational personnel.

This effort implemented model evaluation techniques after their utility has been demonstrated, and supported research scientists in ocean model evaluations. As a result of DAMEE, there was a need to add more sophisticated measures, such as error analysis, space-time spectral decomposition techniques and objective pattern recognition schemes. Once these measures were developed and validated, this task incorporated the measures into ECMOP, as well as transitioned them to operational systems. The 6.3 effort transitioned these techniques to the Naval Oceanography Command as upgrades to the verification module (VERMOD). This and future transitions were addressed as upgrades to the EMS or IDEAS since VERMOD resided within these two systems. Also, many evaluation routines used in meteorology, such as anomaly correlation, skills scores, vector errors, confidence factors, and error tracking were evaluated during DAMEE and were incorporated during FY93.

Data derived from the AI/ES interface to the DBMS was passed to a statistical model that compared the new analysis with the previous history and then statistically derived a new history, such as mean position and variability of a feature. This was returned to the DBMS for future comparison. This could be coupled with model forecasts to give an analyst a "best guess" when an image was partially cloud covered. This was an early phase of an AI/ES application. The plan for FY94 was to begin interactive model tracking on a small scale, using drifter models in a real-time mode. For FY-95, model diagnostics would be used in real-time to monitor model performance, and interactively feedback changes to model parameters to steer the model. This had application to environmental simulations and wargames.

The FY93 major completions and accomplishments consisted of:

- Implementing objective feature analysis scheme;
- Supporting the final evaluation phase of DAMEE-GSR;
- Completing watermass analysis routine modifications for NAVOCEANO, implementing in IDEAS, and transitioning to Navy;
- Completing profile synthesis and extension routines using NAVOCEANO and NRL Stennis algorithms, implementing in IDEAS, and transitioning to Navy;
- Researching applications of AI/ES technology, coupled with statistical models, to the construction of data bases; and
- Investigating the feasibility of incorporating AI/ES feature identification routines into EMS for use with IR imagery and model output fields.

2.3 Scientific Visualization for Model Evaluation Task

This task had an objective to put as much graphics and visualization capability as possible directly on the scientist's desktop workstation/terminal to maximize his effectiveness and productivity. A secondary near-term objective was to perform tasks on separate stand-alone machines, such as the Silicon Graphics Incorporated (SGI) graphics workstations. This included volume rendering, true "3-D" motion simulation, and the generation of professional-quality, multi-parameter, animated renderings of physical ocean processes.

The software developed made use of state-of-the-art visualization systems. The oceanographic community was collecting and generating vast amounts of 4-D

data. These data sets exhibited a high degree of variability over a broad area at very high temporal and spatial resolution, resulting in an immensely difficult task to evaluate the data quality or validity. It had been shown that graphical visualization techniques could greatly enhance the scientist's ability to efficiently and accurately evaluate large amounts of data, modeled or otherwise.

This would be accomplished by giving the scientist an intuitive, interactive graphical interface that allowed communication with and manipulation of any data field selected including model input/output, historical or climatological data, point observations or satellite imagery, or any other data types. The system would allow generation of any graphic necessary with minimal knowledge of the data, where it resided, or how the graphics routine worked. It would provide capability to view it in multiple ways directly on the workstation/terminal. And, it would provide the capability to interact directly with the graphical data display to extract information and initiate other applications without unnecessary intervening menus. This included transparent data exchanges over the network with large scale computers.

This task used a combination of in-house developed, public domain, and proprietary software integrated into a single system based on coupling to the NEONS/DBMS via a graphical user interface (GUI). The GUI would be X-Windows based, function within the UNIX operating system, and be transparent over the network. The primary goal for FY93 was to incorporate fully interactive graphics capability into the GUI, as well as the graphics applications. Additional graphics applications features to be added would include merging different data types into a common graphic display; displaying fields derived from other graphic displays or resulting from mathematical manipulations of primary parameters; and multiple still frames displayed on screen simultaneously to depict a time or space series. All functions would be under the control of the user, who could choose to let the system set default values for a quick look or allow direct setting of any graphic control parameter. With the exception of the proprietary software running on the SGI, all in-house developed software would be incorporated into the EMS and IDEAS, and be transitioned to the Navy with each major system upgrade.

Applications of AI/ES technology to graphics and visualization were also to be investigated. The two areas that would be explored were to design an intelligent online, application sensitive, HELP function; and to design an intelligent module that could be coupled to the GUI to monitor the activity of the user, maintain activity logs, learn the user's trends, and make recommendations on applications based on the user's past activity history. This was a preliminary collaborative effort with the Computer Science Departments of MSU and Tulane.

Another effort was to implement techniques to allow the scientist to visualize the static output of his model and to track the model activity during an animated

simulation. This would be done utilizing the output of the drifter models to visualize trajectories or neutral particle motion. A goal for FY94 and beyond was to provide advanced techniques to allow a man-machine interactive capability with the model while it was running, and thereby steer the model in real time via the interactive display.

The major FY93 completions and accomplishments included:

- A complete upgrade of the GUI to take advantage of fully interactive graphics capability;
- Upgrades to each graphics application to use the fully interactive graphics capability;
- Adding graphics applications to allow data merging;
- Incorporating all upgrades into EMS and IDEAS for transition to the Navy;
- Designing and documenting online HELP function for EMS and IDEAS;
- Working with scientists to identify acceptable drifter models for producing model trajectories.

3.0 FY94 RESEARCH PROGRAM

The FY94 research program was modified to adjust to new Navy Ocean Modeling and Prediction program priorities, especially in the area of coastal and semi-enclosed seas. The overall CAST objectives in FY94 were then to:

- Conduct coastal and semi-enclosed seas ocean modeling basic research, embedded in a CAST modularized software system, with the emphasis on model relocatability to any geographical region and coupling to atmospheric models;
- Support the technical requirements of Navy and university ocean modeling efforts by providing routine day-to-day technical support to the scientific staff, and by designing, developing, and implementing next generation technical support capability to enhance the researcher's ability to develop, validate, evaluate, and transition ocean models; and
- Tailor and transition applicable advanced technical support capabilities developed for the research community to the operational Navy, and to

expedite the transition process by having similar and compatible data management, evaluation criteria, and hardware and software operating environments in both communities.

The emphasis continued to be on modularized software systems, integrated functions, and objective evaluation. Although the major focus was on ocean modeling, most developments were applicable to atmospheric modeling as well.

The CAST plans and milestones supported ocean model prediction/ evaluation and were grouped under three major projects, which were also composed of several tasks as follows:

- Coastal and Semi-Enclosed Seas Relocatable Models Project (6.1 Basic Research)
  - Task 1: Coastal and Semi-Enclosed Seas Modeling
  - Task 2: Database Research for Air-Ocean Modeling
  - Task 3: Scientific Visualization for Model Evaluation
  - Task 4: Ocean Model Verification
- Ocean Model Technology Project (6.2 Exploratory Development)
  - Task 1: Data Management for Ocean Modeling/Simulations
  - Task 2: Evaluation and Validation of Ocean Model Performance
  - Task 3: Development of an Ocean Model Testbed and Production of Reference Ocean Datasets
  - Task 4: Scientific Visualization for Ocean Models and Simulations
- Advanced Development and Transitions Project (6.3 Advanced Development)
  - Task 1: Transition of CAST Applications
  - Task 2: Database Management using NEONS

The basic and exploratory development research efforts directly supported the ocean modeling research and development efforts of NRL and the university modeling communities. The Advanced Development and Transitions Project also supported NAVOCEANO and FNMOC. In the project and task reorganization for FY94, tasks were no longer composed of 6.1, 6.2, or 6.3 components. Accordingly each task spanned only one research category, and thus the prescribed funding for CAST in FY94 of $1,450K was distributed as follows:

	$(K)		
	6.1 Project	6.2 Project	6.3 Project
- Task 1	300	170	200
- Task 2	110	100	125
- Task 3	50	80	
- Task 4	215	100	

This prescribed funding was subsequently reduced by $70,000 in September 1994.

All three projects were again closely coupled, with the CAST Program both vertically and horizontally integrated. All applications developed within CAST continued to interface to the DBMS via NEONS, which had now been accepted for use on POPS facilities under the name Integrated Stored Information System (ISIS). NEONS has also been adopted by the Navy for the Tactical Environmental Support System (TESS) and the NCTCS Integrated Tactical Environmental Subsystem (NITES). Therefore, any applications developed within CAST were still POPS compatible and could be readily adapted to TESS and NITES, with only minimal modifications required for specific system configurations. Although CAST's primary collaboration was with ocean modelers, all research and development issues took into consideration the needs of atmospheric modelers.

3.1 COASTAL/SEMI-ENCLOSED SEAS RELOCATABLE MODELS PROJECT (6.1)

3.1.1 Coastal and Semi-Enclosed Seas Modeling Task

Under this Project, the first task, Coastal and Semi-Enclosed Seas Modeling, had an objective to realistically model coastal regions and semi-enclosed seas. This included shelf-break fronts, the interaction between shallow and deep water eddies, intermediate and deep water formation, and air-sea-wave interaction. CAST used the DieCAST (Dietrich-Center for Air Sea Technology) ocean model which evolved from the Sandia Ocean Modeling System. DieCAST is a hydrostatic, incompressible, rigid-lid, partially implicit, fully conservative model that uses an Arakawa "c" staggered grid. Recent tests on DieCAST showed remarkably similar results with validated models, a much faster computational speed, and easy relocation to any geographical region of the globe. DieCAST was configured for several regions and was able to use unfiltered bathymetry.

The initial efforts were to refine and extend DieCAST to the Mediterranean Sea (shallow water), embed it in the CMES, and then evaluate it by comparing its results with observations and with a previously validated model. Once this was completed, DieCAST was evaluated in the Straits of Sicily. The next phase will be to couple the shallow water DieCAST model to the NRL deep water model.

In the research on the dynamics of intermediate and deep water formation through penetrative convection processes, the effort was to evaluate the Prandtl number, Reynolds number, resolution, and non-hydrostatic effects in 2D/3D penetrative convection models; to study penetrative convection and its effect on larger scale environments (intermediate/deep water formation); and to develop modeling/parameterization strategies for penetrative convection and intermediate/ deep water formation.

Thus in FY94, CAST configured DieCAST for the Straits of Sicily, South China Sea, Labrador Current, and North Atlantic Basin, and ingested DieCAST output into the CMES; compared DieCAST with observations and the Sandia Ocean Modeling System; and evaluated DieCAST by applying it to hurricane forced flows, particularly with respect to air-sea-wave interaction and mixed layer dynamics, and to regions of strategic interest.

Another element of this task involved model relocation. It is a complex process to set-up a numerical ocean model for any given region in the world, particularly in semi-enclosed seas. The modeler has the task of manually assembling the various model components. The necessary data sets of bathymetry, wind-forcings, tides, observations, and transport exist in different formats and resolutions. After the data are selected and extracted, they need to be interpolated to the model grid in its coordinate scheme. With any change, the above steps need to be reiterated. Then, the model is often run on a different computer system, where the results are returned to be visualized and evaluated. It is highly desirable to have a system wherein all of these steps can be efficiently performed within a common computing environment and automated to the maximum extent possible.

The development of such a system was started by CAST in FY94, in collaboration with Dr. Lakshmi Kantha at the University of Colorado. During Phase I, a prototype was built on NEONS using Dr. Kantha's 2D tidal model. The modeler selected the region of interest, the bathymetry, and the gridding scheme. The Swiderski datasets provided the tidal information at the open boundaries. Then selected coastal station data were interpolated to the model grid to provide the initialization field. After the model was run, the existing suite of CAST tools in the CMES were used to visualize the data.

The relocatability and versatility of the DieCAST model was also demonstrated in FY94. In particular, DieCAST applications to classical two-dimensional and three-dimensional wake vortex street patterned after Barbados Island, and the Gulf of Mexico with high resolution of 1/12 degree, have been completed. In collaboration with several researchers, DieCAST has also been applied to the Pacific Ocean east of Australia and east of New Zealand, the Nova Scotia continental shelf, Hudson Bay, and to the Great Lakes, where the research is still ongoing. In late FY94, modeling with DieCAST will be expanded to the California Current and the North Atlantic Basin.

3.1.2 Database Research for Air-Ocean Modeling Task

The objective of this task was to conduct the research and development necessary to optimize all aspects of data management in support of air-ocean modeling. This included investigations into the use of relational versus object oriented DBMS, knowledge discovery, data models, metadata, data filtering, clustering techniques, and synthetic data. A secondary, but vitally important, objective was to apply state-of-the-art DBMS technology to support other NOMP 6.1 air-ocean modeling efforts. This involved the continuation and acceleration of present efforts to acquire, consolidate, and archive unique and important datasets for application to model initialization, evaluation, and verification. The vehicle for implementing this effort was a single, integrated DBMS that circumvented the need for duplicate archives, and eventually would operate in a distributed heterogeneous computing environment. This task relied heavily upon operational model output produced by the FNMOC and NAVOCEANO, augmented with research quality databases acquired from other sources. Specification of data requirements for initialization and verification was accomplished in coordination with CAST, NRL, and other academic modelers.

This task was composed of several elements. The first was the investigation of AI/ES applications (knowledge discovery, data mining, and clustering). Here CAST collaborated with Dr. Fred Petry and graduate student, Mr. Patrick Perrin of the Tulane University Department of Computer Science to develop an automated intelligent, high-level querying system for searching large numerical databases, and with Dr. Susan Bridges and graduate student, Ms. Dongmei Wu of the MSU Department of Computer Science in the area of knowledge acquisition and representation as applied to ocean model databases. In the second task element, CAST collaborated with Dr. Julia Hodges and graduate student Mr. Chandrashekar Ramanathan of the MSU Department of Computer Science where the focus was on exploring object-oriented database technology and how it could best be applied to ocean modeling.

Thus in FY94 CAST completed the preliminary design of a knowledge discovery system based on clustering techniques; implemented an on-line data browser to the DBMS; completed preliminary efforts to apply object-oriented technology to data storage/retrieval via NEONS; added database administrative tools to BROWSER which allowed users to add new models and geographical regions; and NOMP funded DBMS research leveraged the development and transition of MOODS to POPS.

3.1.3 Scientific Visualization for Model Evaluation Task

The objective of this task was unchanged from FY93 as discussed earlier in Section 2.3. The emphasis was to conduct basic research into graphics and visualization, where the focus was on the development of new algorithms for volume rendering, tailored to the analysis of oceanographic data types. CAST also researched graphics and visualization applications towards the design and development of blending modeled ocean features for tactical and strategic scenario simulations.

The MSU Engineering Research Center, Dr Robert Moorhead and graduate student Mr. Zhifan Zhu in exploring some basic issues in the 3D visualization of ocean data, initially developed the Ocean Visualization Interactive Research Tool (OVIRT2). CAST, in exploiting what was learned in this research, embarked upon a new area of visualization research involving oceanographic feature identification and rendering. Included was the development of algorithms and techniques for:

- Automatic identification and extraction of ocean features in a 4D data set,
- Rendering the surface of features such as eddies,
- Derivation and display of feature movements (such as eddy center velocity),
- 3D animations, and
- Investigating techniques to display vector fields in 3D.

Another task emphasis was to use these developed visualization techniques to support basic ocean modeling research. The goal was to give the scientist an intuitive, interactive graphical interface that allowed communication with the DBMS and manipulation of any data field selected including model input/ output, historical or climatological data, and point observations or satellite imagery. This effort used a combination of in-house developed, public domain, and proprietary software integrated into a single system based on coupling to the NEONS/DBMS

via a GUI. The GUI was X-Windows based, functioned within the UNIX operating system, and was transparent over the network.

Thus, in FY94 CAST designed a system to display synchronized time animations of two different cross-sections of ocean model fields; upgraded applications to use interactive graphics capability; coupled OVIRT volume visualization software with CMES; completed preliminary designs for 3D vector and neutral particle trajectory plots; designed and developed 2D eddy tracking algorithms; and designed 2D and 3D feature extraction algorithms.

3.1.4 Ocean Model Verification Task

The objective of this task was to collaborate with ocean modelers on the research, design, and development of model verification and evaluation techniques, user interfaces, and systems. This included examining the utility of both objective and subjective routines, and incorporating them into the CMES.

Except for a few standard model evaluation criteria, such as root mean square error and pattern correlation, there are few common standards for model verification and evaluation existing in the ocean modeling community, and thus the process of establishing model evaluation criteria and the intercomparison of the various models is difficult. Part of the difficulty is due to ocean models being both regional and feature specific.

The first planned emphasis, as a follow-on to the recently completed DAMEE (Gulf Stream) model evaluations conducted during the past two years, was to conduct a survey of the ocean (and atmospheric) modeling community to ascertain and examine the various model evaluation techniques currently employed. Initial questionnaire input from the modelers was to be supplemented by personal interviews. This effort was delayed and was not funded for future research.

Another FY94 focus area was to directly collaborate with PIs from USM's COAM and their DAMEE and SEACOAST Projects; with Dr. Allan Robinson on improvements to the CMES which has been transitioned to Harvard University; with Dr. John Harding and associates at NRL on use of the CMES; Dr. Lakshmi Kantha of the University of Colorado, where the CMES had been transitioned for use with relocatable ocean modeling systems; and Dr. Louise Perkins of USM's Scientific Computing Program, who would be conducting a test/evaluation of the CMES.

Thus in FY94 CAST reported on the feasibility of an objective feature analysis scheme; supported the final evaluation phase of DAMEE (Gulf Stream); transitioned CMES, BROWSER, and IDEAS applications to the NRL Tactical

Oceanography Wide Area Network (TOWAN) user community; enhanced CMES by adding model analysis and evaluation tools; transitioned CMES to the University of Colorado in support of research funded by NRL Code 7320; developed and implemented numerical algorithms to track eddies to determine point location relative to a polygon, and to automatically locate, contour, and track ocean features; and designed and implemented graphics applications to display trajectories utilizing neutral particles for model tracking.

3.2 OCEAN MODEL TECHNOLOGY PROJECT (6.2)

3.2.1 Data Management for Ocean Modeling and Simulations Task

The objective of this task was to follow a developmental pathway that led to efficient, flexible and economical management, processing and access to oceanographic data within the Navy, eventually culminating in a distributed database environment for the ocean research community, as well as one that also supported operational Navy requirements. The Navy payoffs would be:

- A reduction in expenses for proprietary RDBMS engine licenses,
- A reduction in media requirements (duplicate datasets),
- Control over data proliferation,
- Increased efficiency in locating file-based datasets,
- Added functionality for NEONS databases,
- More powerful profile editing capability for oceanographic analysts and researchers,
- Hardware/software maintenance support for USM COAM during FY94, and
- Continuing technological assistance to Navy users of NEONS and CAST developed systems.

As in FY93, CAST continued to champion NEONS as the data management tool of choice for both the ocean research community and the operational Navy. NEONS was now the management system among a growing list of Navy and non-Navy users, and was the logical starting point for developing the network database capabilities needed by Navy oceanographers. CAST responsibilities under the TOWAN Contract with NRL presented an exceptional opportunity for leveraged funding of NOMP Program and other Navy data management requirements.

Development of "netNEONS" was done using NOMP funded university cooperative student hires. CAST also did version upgrades to IDEAS and the NEONS Browser, and developed a distributed database capability by combining NOMP and TOWAN resources. The development of additional generic data types for NEONS was coordinated with NRL.

Thus CAST FY94 accomplishments included:

- Developing "netNEONS" and the Network Browser;
- Providing data management support to USM COAM;
- Developing and transitioning IDEAS 1.0 to NRL;
- Developing and transitioning NEONS Browser 1.0 to TOWAN;
- Beginning the design of data tools for NEONS Browser 2.0.

3.2.2 Evaluation and Validation of Ocean Model Performance Task

The task objective was to provide the Navy with the capability to establish ocean model performance benchmarks and criteria, to provide the tools for conducting these measurements, and to establish the means whereby performance characteristics can be clearly demonstrated and observed in both subjective and objective contexts. Performance must be measured against both real world data and statistical indices. Advanced visualization tools play a significant role in model behavior analysis. In this task, CAST applied complex statistical algorithms, pattern recognition technology, image processing technology and other promising technology in achieving the objective. We pressed for consensus among ocean modelers regarding standards, benchmarks and evaluation criteria. The long range objective was development of an ocean monitoring system which received real-time input, performed prediction calculations, made adjustments through error feedback, and provided a "best available" status of an oceanic region at any given time. This evaluation and validation capability would monitor the performance of this futuristic system. The Navy payoff included:

- Improved confidence in its operational models,
- Verified model performance criteria,
- Basis for making model replacement/upgrade decisions,
- Better performing ocean and acoustic models,

- Higher quality information for Navy tacticians, and
- Improved oceanographic analysis.

The objectives were implemented through version upgrades to the CMES. This system incorporated NEONS which provided support for all known generic data types of importance to the oceanographer. The system underwent continual enhancement from its prototype development stage to the present version. The CMES now offered superior visualization functionality including 2D animation, contour and vector plots, and volumetric display with rotation and slicing. The CMES visualization capabilities benefitted from the technical advances seen in other tasks such as 3D animation, volumetric rendering (also animated), lighting and shading controls, transparency controls, and 3-D rotation (also animated). Commercial off-the-shelf software was employed where it provided the appropriate level of functionality. New statistical tools were added to perform error analysis, space-time spectral decomposition, objective pattern recognition and complex correlations. AI/ES capability was investigated in FY94 for potential application to the evaluation and validation objective.

3.2.3 Development of an Ocean Model Testbed and Production of Reference Ocean Datasets Task

The objective of this task was to develop an ocean model testbed for use in various Navy simulations and tactical activities, with application to operational needs and development questions requiring testing under realistic ocean conditions. This project was delayed in FY94 and was not funded in FY95.

3.2.4 Scientific Visualization for Ocean Models and Simulations Task

The objective was to expand the capability of the Navy research modeler to do advanced visualization on his/her desktop workstation to maximize the individuals effectiveness and productivity. This allowed the scientist to put their primary focus on the science rather than on technical development issues. At the same time, the most important payoff was to transition a similar capability to the Navy operational community. The cost savings in time and personnel resources were enormous. A secondary near-term objective was to perform advanced visualization tasks, currently demanding high-end graphics hardware, on separate stand-alone platforms such as SGIs. The advanced visualization objective included volume rendering, true 3D motion simulation, and the generation of professional-quality, multi-parameter renderings of ocean processes. The Navy payoff was that most graphics work could be performed on the scientist's desktop workstation, where costs in time and resources will be minimized, and only a small percentage

of the more demanding graphics and visualization will be done on the more costly high-end workstations.

The visualization software developed was state-of-the-art, and provided the scientist with an intuitive interactive GUI allowing full communication and manipulation of any data field selected. This included model input or output, historical or climatological data, point observations, and satellite imagery. The system developed allowed for the generation of graphical displays with minimal knowledge of the data characteristics itself, of where the data was located, or of how the graphics routine functions. It provided the researcher with the capability to display the data directly in multiple ways and provided him/her with the capability to interact directly with the graphical data display. CAST continued to use a combination of in-house developed, public domain, and proprietary software, integrated into a single system based on coupling to the NEONS/DBMS, via the GUI.

Thus in FY94 CAST incorporated a fully interactive graphics capability into the CMES and other CAST-developed applications; and completed a 3-D visualization case study software package and integrated it into the CMES, using GL libraries on a SGI platform.

3.3 ADVANCED DEVELOPMENT AND TRANSITIONS PROJECT (6.3)

3.3.1 Transition of CAST Applications Task

The objective was to conduct 6.3 advanced development research and transition CAST products and capabilities, developed under 6.1 and 6.2, to the Naval Oceanography Command.

CAST developed three products, the CMES, BROWSER, and IDEAS. These were built on NEONS and all could be used by various researchers and operational centers to quality control the model and observations. They were also interactive, user friendly, and configured to work in the X-window environment. The applications operated independent of time and spatial constraints, and automatically configured themselves by using information from the database. This allowed researchers to migrate among different regions of the world, without having to overhaul the software and analysis tools.

The CMES application allowed researchers to visualize model data and compare it with observations including satellite images. The application supported contours, vectors, overlays, coastlines, animation cross-sections, graphics, zooming, printing, and postscript outputs.

The BROWSER application allowed a user to interact with the database and determine the availability of data for the desired time and spatial coordinates. The application was user-friendly and was intended to shield him/her from the complexity of the database. The application also supported database administration functions such as adding new models, parameters, deletion of data, and consistency checks on the database.

The IDEAS application allowed users to examine observations (XBTs, AXBTs, etc.) and tag them as good, bad, or suspect. IDEAS facilitated data visualization and aided the analyst in conducting quality control procedures on the observations. It also allowed an analyst to edit the suspect data and create a new data set without altering the original database. IDEAS included a flat file interface for read and write functions, that performed as easily as database access since the analysis and visualization functions were modular and independent of input/output methods.

Following the FY93 transition of CMES, BROWSER, and IDEAS prototypes to FNMOC, NAVOCEANO, and elsewhere, in FY94 CAST also transitioned operationally relevant upgrades to BROWSER and IDEAS. We began integrating the 3D volume capability into all CAST applications. We also added a greater variety of import/export formats to BROWSER. One criticism from both the operational and research communities on NEONS utility was the requirement for extensive oversight by an expert in database administration, particularly with respect to setting up NEONS tables for new data sets. Accordingly, CAST began development of several database administration tools that significantly simplify the creation of new data sets for NEONS.

Thus in FY94 CAST completed profile synthesis routines, incorporated into IDEAS, and transitioned; leveraged CMES and BROWSER development into the NAVOCEANO MOODS and NIDAS projects; and transitioned IDEAS and BROWSER to NAVOCEANO.

3.3.2 Database Management Using NEONS Task

The objective was to use NEONS as the standard model for environmental data, and the vehicle for transitioning advances in data management technology to FNMOC and NAVOCEANO.

This task was composed of three elements. The first was ISIS (Integrated Stored Information System) and NEONS compatibility. The Naval Oceanography Command developed ISIS as the RDBMS model for implementation within its supercomputing environment. ISIS was derived from NEONS and was configuration managed by FNMOC, however, NEONS remained in use as the

environmental database model adopted by a growing number of Navy organizations and other Federal agencies including SPAWARS. While retaining its similarity to NEONS, ISIS responded to data management requirements and issues that are uniquely mission critical to FNMOC. This research addressed the need to maintain compatibility between NEONS and ISIS as each database model evolved to meet the needs of both operational and research community users.

The second element involved enhancements to NEONS and future consideration for ISIS. A 3D volume data type was developed by CAST in FY93 and incorporated into NEONS in FY94. CAST also completed development of the dynamic structured query language (DSQL) code for NEONS, and integrated it into NEONS. The 3D volume type supplements or replaces the grid data type in NEONS and the DSQL supplements or replaces the LLT and line data types. This was important in that the number of data types (and code) needed was reduced. It also allowed more flexible query and extraction of data in user applications.

The third element was netNEONS Development. The earlier version of NEONS required a proprietary RDBMS license on every platform that needed access to the database. A "client server" version of NEONS, termed netNEONS was developed to obviate the need for the proprietary RDBMS license on local platforms. netNEONS now provided a complete and transparent interface between the applications running on the local platform and the database server running on a remote platform. This meant that only one proprietary license was required for the remote server. This not only substantially reduced the costs for a multi-user system, but also improved overall system efficiency since all applications were run on the local platform and only the data was moved between the database server and the local application.

Thus in FY94 CAST added 3D volume data type to NEONS; designed and developed code for DSQL addition to NEONS; and completed a preliminary design and prototype for netNEONS.

4.0 FY95 AND FY96 PLANNED RESEARCH

For FY95 and FY96, the Office of Naval Research significantly reorganized its funding procedure for CAST. The previously fully integrated basic, exploratory, and advanced development research programs were abandoned with the research now restructured under programs organized strictly by principal investigator. Of 19 CAST planning letters submitted to ONR in March 1994, eight were approved for the preparation of full proposals. Of these, five were selected for full or partial funding. The levels of funding for these projects was $892,897 or approximately 56 percent of the $1,580,904 requested, and approximately 68 percent of the funding levels in FY93 and FY94.

This reduced funding, together with the $70,000 FY94 budget cut announced in late FY94, could severely impact the CAST research and development program in FY95/96, as well as future planning, both long range and short range.

The five projects selected for FY95/96 funding were:

- High Resolution Coastal Model Studies
- A Unified Air-Sea Visualization System
- Relocatable Numerical Models of Marginal, Semi-Enclosed, and Coastal Seas
- CAST participation in DAMEE-North Atlantic Basin
- Software Transitions to NAVOCEANO and TESS

A brief discussion of this planned research is provided in the sections that follow.

4.1 High Resolution Coastal Model Studies Project

The objectives of this project are to develop a high resolution model that realistically and efficiently simulates coastal ocean dynamics, including density fields and tidal effects, to test the model in the LATEX Gulf of Mexico and the California Bight Regions, to relocate the model to regions of strategic interest such as the Yellow Sea, and to transition the model to the Navy. The Co-Principal Investigators are CAST researchers Dr. David E. Dietrich and Mr. Alberto Mestas-Nunez.

With the Navy's new emphasis on coastal and shallow water regions, there is a need for high resolution models that realistically and efficiently simulate coastal conditions. No existing model can do it all. The Navy Layered Model is ideal for deep water applications. Sigma coordinate models are good for shallow regions but are less accurate in regions of large amplitude topography. There is a need for a good intermediate model to bridge the gap between shallow and deep water, and DieCAST appears capable of meeting this need.

In FY95, CAST will replace the present rigid-lid on the DieCAST model with a free-surface, couple this new version with a mixed layer model recommended by NRL, and add variable latitudinal and longitudinal spherical coordinate increments to obtain higher resolution in coastal and northern ocean regions.

In FY96, the improved version of DieCAST will then be coupled to the Navy Layered Ocean Model using a nested grid approach. CAST will also add curvilinear metrics to the model equations for treatment of shelfbreak dynamics, add full data assimilation to DieCAST, and finally perform model evaluation initially in the California Bight Region, and in the Gulf of Mexico, if additional funding is obtained.

The planned funding for this project is $200,000 in FY95 and $200,000 in FY96.

4.2 A Unified Air-Sea Visualization System Project

The objective of this project is to create a system for Navy modelers in which any knowledgeable user can effectively and efficiently visualize an environment, that is as realistic as possible without sacrificing physical reality.

The Co-Principal Investigators are Dr. Robert J. Moorhead, MSU Engineering Research Center; Mr. James H. Corbin, CAST; and Dr. Bernd Hamann, MSU Engineering Research Center.

The visualization system must be easy to use and be able to deal with any reasonable description of information within the spatial extent of the visualized environment. The system should automatically scale and convert data to the appropriate resolution ranging from high resolution coastal and semi-enclosed seas to lower resolution ocean basin scales. Applications would include tactical platforms (e.g., ships and acoustic receivers), contextual information (e.g., coast-lines and topology), and environmental parameters (e.g., flow rates, temperature, and salinity), any of which could be time-varying. The user should also have the ability to navigate in anyway through the environment and pause or restart the animation if desired. Above all, the representation and information transfer must be physically accurate, as well as aesthetically pleasing.

The first of four steps involved in this project is to determine the principal existing air and sea gridding structures. Second, a spherical curvilinear gridding system must be developed, including routines to produce hierarchical, boundary conforming, spherical, and curvilinear grids with local geometrically-driven environment. Third, data interpolation and approximation techniques must be developed for mapping data from multiple models, measurements, and archival sources onto the spherical grid. Here, routines to approximate and interpolate scattered data, and data on unstructured and structured grids will be developed. Finally, scalar and vector field visualization paradigms will be developed for environmental data stored on a hierarchical spherical curvilinear gird. The mapping and visualization routines will be developed in collaboration with and tested by

various ocean and atmospheric modelers to assure the utility, validity, and functionality.

The planned funding for this project is $250,897 in FY95 and $205,709 in FY96.

4.3 Relocatable Numerical Models of Marginal, Semi-Enclosed, and Coastal Seas Project

The objective of this project is to facilitate a rapid transition of relocatable numerical models of marginal, semi-enclosed, and coastal seas being developed at the University of Colorado to NAVOCEANO. The models will be designed to have a generic user-friendly GUI front-end on top of relocatable modeling environment (RME) software, and will be configured to run in any region of the world's oceans with relative ease. The Co-Principal Investigators are Mr. Valentine Anantharaj of CAST and Dr. Lakshmi Kantha of the University of Colorado

In FY94, the University of Colorado developed a two-dimensional readily relocatable, nestable, data assimilating numerical model of tides in marginal and semi-enclosed seas. This model has been applied to several areas of Navy interest, and has shown skill in depicting tidal sea surface heights, and model output has been used to deduce altimetric sea surface heights as well. In FY94, CAST incorporated a user-friendly GUI into the RME that facilitates configuration of the model to any region of the world. The 2D barotropic tidal model has been transitioned to NAVOCEANO.

For the first task in FY95, the University of Colorado in collaboration with CAST, will develop a 2D model for storm surge and atmospheric pressure response in coastal, marginal, and semi-enclosed seas. CAST will also extend the GUI to facilitate extracting time and space varying wind and pressure fields.

In the second task, CAST will incorporate University of Colorado developed altimetric analysis packages within the RME using NEONS. The third task, beginning in FY96, is to follow the 2D models with a sigma coordinate based, comprehensive physics 3D tidal model with data assimilation in coastal regions. The CAST role will again be to design and build the GUI, and transition the system to NAVOCEANO. The final step, planned for FY97, is to extend the system and methodology to 3D numerical circulation models that assimilate observed data including altimetric and insitu.

The planned funding for CAST in this project is $132,000 in FY95 and $140,000 in FY96. Research conducted by the University of Colorado is covered under a separate research grant.

4.4 CAST Participation in DAMEE-North Atlantic Basin Project

The objective of this project is for CAST to participate in the Data Assimilation and Model Evaluation Experiment for the North Atlantic Basin (DAMEE NAB) including dataset development, quality control, and archival/ distribution center. The objective is to ensure the availability of the highest quality datasets for DAMEE. The Principal Investigator is Mr. Valentine Anantharaj of CAST.

The Gulf Stream DAMEE demonstrated the important role data plays in ocean modeling. Data are a controlling factor, and a common starting point in the assimilation and evaluation process. Verification datasets are the standards for measuring model performance, and all phases of DAMEE NAB will produce suspect results if less than close attention is given to the quality of data provided to modeling groups. The data must be representative of the real environment. CAST expects to generate and maintain the basic datasets selected for DAMEE NAB within the proposed level of effort.

CAST will collaborate closely with USM COAM researchers and others primarily responsible for DAMEE NAB in monitoring dataset generation and in addressing data issues. CAST intends to process the datasets needed, and as necessary interpolate the datasets to the different model grids. We will also provide an accurate and comprehensive climatology for the region, as well as an accurate bathymetric dataset.

CAST will make available to the DAMEE modeling groups datasets as flat files and via access to NEONS, both resident on a 187 gigabyte fileserver. CAST evaluation, verification, and visualization systems will also be available to all modeling groups. CAST will also maintain a World Wide Web server to support DAMEE in the dissemination of data results and other information.

The planned funding for this project is $60,000 in FY95 and $60,000 in FY96. In this effort CAST will be a subcontractor to USM COAM.

4.5 Software Transitions to NAVOCEANO AND TESS Project

The objective is to transition to NAVOCEANO and the Tactical Environmental Support System (TESS) several systems (including upgrades and new systems) developed by CAST under 6.1 and 6.2 funding from the NOMP Program. The Principal Investigator for this project is Mr. James H. Corbin of CAST.

In collaboration with NAVOCEANO, CAST researchers in FY94 determined that the systems most needed by NAVOCEANO and ready for

transition were the BROWSER, the Relocatable 2D Tidal Model, and the Relocatable Wave and Surf Model. The plan for FY95/96 is to complete the transition, to incorporate those changes necessary to tailor these systems for operational use, and to prioritize the transition of other systems. Additionally, a 3D Relocatable Tidal Model and an upgraded Wave/Surf Model when completed in FY95 will also be transitioned. The last effort proposed for FY95 is to continue the port to the TESS platform of all applicable high end graphics and visualization tools developed under the NOMP program.

The planned funding is $250,000 in FY95 and $250,000 in FY96.

4.6 Current Thrust Areas and Deliverables

In the past, MSU CAST technical research and development has produced tools, systems, techniques, and procedures that improve efficiency and overcome deficiency for both the operational and research communities residing with the Department of Defense, private industry, and the university ocean modeling community. We intend to continue this effort by adopting objectives for 1995 and beyond that are even more closely focused on these requirements. The primary CAST thrust areas in FY93 and FY94 were:

- To develop advanced methodologies and tools for model evaluation, validation and visualization, both oceanographic and atmospheric,

- To develop a system-level capability for conducting temporally and spatially scaled ocean simulations that are driven by or are responsive to ocean models, and take into consideration coupling to atmospheric models,

- To continue the existing oceanographic/atmospheric data management task with emphasis on distributed databases in a network environment, with database optimization and database standardization, including use of Mosaic and World Wide Web (WWW) access, and

- To implement a high performance parallel computing technology for CAST ocean models.

The CAST approach employs the most recent technological advances in database management, graphics/visualization, and network communications including the WWW. CAST deliverables will include:

- Implementation of a laboratory-like capability for oceanographic and atmospheric model evaluation and validation that incorporates measurements of performance skill,

- Development of high resolution coastal models based on DieCAST,

- An economical data access solution and distributed database capability for networked database users (including DOD components),

- New model visualization and animation tools for analyzing and assessing model output, and

- Development and implementation of network file browsing capability and use of Mosaic and the WWW for general database access and educational applications.

4.7 Current Facilities and Personnel

CAST software has been developed using Sun Microsystems and Silicon Graphics Inc. (SGI) workstations in a network configuration. The UNIX operating system, X-Windows client-server model, and the Open Software Foundation's Motif widget set are the cornerstones. The primary computer languages are "C", Fortran and X-Windows; during the coming year CAST will also develop expertise in "C++", SGI proprietary "GL" and/or "OpenGL".

CAST is heavily invested in state-of-the-art computer hardware including an internal network of Sun Sparc (1's, 2's, & 10's) and SGI Indigo Extreme Graphics workstations and X-terminals. The network consists of a Sun Sparc 1000 File-server integrated with a magneto optical "jukebox" file storage system having a 187 gigabyte capacity on 144 internal platters, and six gigabytes of internal magnetic media storage. In addition CAST maintains an SGI Model 340-GTXB computer which supports graphics and visualization requirements. It also provides direct, high speed, local area network access to one of the Navy's largest supercomputing resources, a CRAY Y-MP with eight parallel processors and 128 million bytes of memory, located at NAVOCEANO. Remote users may access any systems on-line using the TELNET utility. Output can be routed to on-line optical disk and video tape recording equipment. Hard copy is available from four 300 dpi laser printers, a high speed line printer, and a 300 dpi thermal wax transfer color printer. Additionally, all administrative and management staff, utilizing a combination of MacIntosh and PC desktop computers are connected to the same network as the scientific and technical staff so that email and files can be readily exchanged.

At present, the Center consists of 18 permanent staff members including oceanographers, meteorologists, software engineers, fluid dynamicists, mathematicians, programmers, computer technicians, and administrative personnel. CAST also has an active program with four research affiliates (academic faculty) and five graduate students from the MSU and Tulane University Departments of Computer Science, as well as the MSU NSF-sponsored ERC. In 1993 and 1994, CAST supported 20 graduate and undergraduate students. This included five students through the MSU Cooperative Education Program, as well as students from the University of Southern Mississippi, University of New Orleans, Louisiana Tech University, Oregon State University, and Brandeis University. CAST is presently located in the Mississippi Technology Transfer Center (Building 1103) of the Stennis Space Center (SSC), a major focal point of federal science, engineering, and technology efforts with nearly 4,000 employees.

APPENDIX I

LEVERAGED RESEARCH PROJECTS

A. RESEARCH PROJECT WITH NAVOCEANO FOR THE MIGRATION OF THE MASTER OCEANOGRAPHIC OBSERVATIONS DATA SET (MOODS) AND SURFACE CURRENT DATABASE (SCDB) FROM THE UNISYS TO THE PRIMARY OCEAN PREDICTION SYSTEM (POPS)

The overall objective was to migrate the MOODS and SCDB from the UNISYS Mainframe scheduled to cease operations in late FY93, to the Sun/Cray environment with uninterrupted service to the Fleet. This transition utilized the EMPRESS RDBMS and NEONS as the database engine and data model. The Principal Investigator for this project was Ms. Cheryl Cesario of CAST.

The EMPRESS/NEONS based MOODS and SCDB were to perform all the functions of the present UNISYS Systems and include additional data file access restraints. A MOODS user access software application was developed utilizing the data classification and instruction review codes in the header of each data observation to control database access, properly tagging new data loaded into the database and exporting data to authorized users, in addition to the security protection inherent.

CAST accomplishments under this project included:

- Designed and developed the MOODS Data Management System (MDMS) to control database access, to properly tag new data loaded, and to export data to authorized users.
- Added administrative and utility functions, as well as data observation header information, to the MDMS.
- Added products such as distribution plotting, histogram, accumulation plot, depth versus parameter plot, and printing of the header information/ audit log.
- Designed and developed a SCDB software application to control database access, to import new data into the database, export data to users, generate inventory totals, observations listing, and product plots.
- Developed and transitioned to NAVOCEANO an EMPRESS/NEONS based MDMS and SCDB Database System.

- Assisted NAVOCEANO in transferring MOODS and SCDB databases from UNISYS to the POPS, and trained personnel in system implementation, usage, and maintenance.

- Linked MDMS with IDEAS.

This $130,000 project was completed on 31 July 1994. No follow-on research is anticipated.

B. RESEARCH PROJECT WITH NAVAL RESEARCH LABORATORY FOR TACTICAL OCEANOGRAPHY WIDE AREA NETWORK SUPPORT (TOWAN)

The objective is to provide technical support services in the areas of data management, data acquisition, hardware/software acquisition and maintenance, and personnel training to NRL in their effort to establish a wide area network as a part of the Defense Simulations Internet (DSI). The Principal Investigator for this project is Mr. M.S. Foster of CAST.

The first task, Data Acquisition, Ingestion and Management, required assistance to NRL in the acquisition and quality control of TOWAN data sets. Data was maintained within NEONS and stored on magneto-optical read/write media. CAST assisted with systems and data management functions until NRL personnel had been trained. The second task, Development of Ocean Model Testbed Data Sets in Coastal Regions and Semi-Enclosed Seas was to assist in investigating and implementing datasets of interest to NRL. The focus was on environmental data distributed by FNMOC. The third task, Hardware and Software Architecture Procurement, Installation and Maintenance, required procurement of compatible computer hardware equipment and proprietary software necessary for systems, database and graphics support of the TOWAN main network node. The final task, Training and Technical Support, provided services to NRL in database administration, systems administration, application design/development, and software integration.

CAST accomplishments to date in this project include:

- Procured, installed and tested two 60 gigabyte fileserver/magneto-optical jukebox systems for use.

- Installed and tested NEONS and proprietary software (Empress and UNIRAS) on the fileserver for TOWAN access.

- Installed and tested the CMES, IDEAS, and BROWSER in the network fileserver environment for TOWAN user access.
- Completed training of NRL personnel.
- Assisted NRL in re-establishing TOWAN connectivity after their relocation to a new building.
- Installed Oceanographic and Atmospheric Master Library (OAML) on the classified fileserver for TOWAN access.
- Procured, installed, and tested tape backup units.
- Installed upgrades of CAST software.

This project has been funded at $717,000 in FY93 and FY94. The project should continue in FY95 but funding has not yet been determined.

C. RESEARCH PROJECT WITH NAVAL OCEANOGRAPHIC OFFICE FOR THE NAVY INTERACTIVE DATA ANALYSIS SYSTEM (NIDAS)

The objective of this project is to provide NAVOCEANO with an interactive overlay capability for several types of oceanographic, meteorological, and satellite derived data; create 3-D gridded fields of temperature and salinity profiles constructed from a combination of "provinced" data (user derived) and gridded data; and a user's manual and training of NAVOCEANO personnel in the new software system. The Principal Investigator is Mr. Dharmesh Krishnamagaru of CAST.

Under this three phase project, the Phase I tasks were to ingest static databases into a CAST installed EMPRESS/NEONS system; prepare draft and final design/database specification documents; ingest revolving databases into EMPRESS/NEONS (Regional GOODS BT's, regional GOODS buoys, MCSST grids, OOC composites, NAVOCEANO regional OTIS, and NIDAS 3D T-S fields created by applications programs); design and develop application programs to interactively view and evaluate the OTIS fields by comparison with Horizontal Contours (OTIS), MOODS, GOODS, Polygon Browse, and Bathy/Shoreline data fields; design and develop application programs to interactively view and evaluate OTIS fields by comparison with Province Definition, OTIS/Clim Transect Definition, Synthetic Profiles, and Horizontal Contours (clim) data fields; design and develop additional application programs to provide the capability to interactively view and evaluate the OTIS fields by comparison with Frontal Composites and Satellite Image (SST) data fields; assist NAVOCEANO in

interfacing the system to the classified POPS via the LAN to ensure the continuity of NIDAS operational commitments; train NAVOCEANO personnel in NIDAS system operation; and provide informal monthly demonstrations on NIDAS.

The Phase II effort in this project is to make the system relocatable on short notice to any area of the world of local or regional size. This involves the design and development of additional application programs to provide the capability to interactively view and evaluate the OTIS fields, developing a regional definition interface to establish new analysis regions, ingesting additional databases and model outputs, and designing and developing interactive software for wave fields.

Phase III provides for enhancements and modifications to the systems developed in Phases I and II. This involves the ingestion of new datasets and software changes that are presently not identified by NAVOCEANO.

Phase I was completed in November 1993 with funding of $199,000. Phase II is in progress and will continue into FY95. Funding of $128,600 has been received. Phase III should continue into FY96.

D. RESEARCH PROJECT WITH ARMY COASTAL ENGINEERING RESEARCH CENTER FOR DEVELOPMENT OF A GRAPHICAL USER INTERFACE FOR THE COASTAL ENGINEERING DATA RETRIEVAL SYSTEM (CEDRS)

The CEDRS consisted of 22 microcomputer-based regional databases of climatological data for the Army Corps of Engineers coastal districts. CAST was tasked to develop a prototype GUI with integrated RDBMS for CERC users to access these datasets. The Principal Investigator was Mr. M.S. Foster of CAST.

The GUI allowed users to define new geographic regions or choose from existing predefined coastal regions. Once the region was defined, the user could then select from existing datasets and export selected data to files. Data types to be represented within the integrated database included CERC Wave Information Study (WIS) hindcast time series data, statistical tables for WIS hindcast data, observational data from the National Data Buoy Center, tidal constituent information, and storm surge data. The developed interface included visual display of regional maps, data exportation to ASCII and/or netCDF format files, ingestion of data from existing data formats, and software hooks for future upgrades.

This $24,000 project was completed on 30 November 1993. System upgrades should be added in FY95 under new funding anticipated to be about $22,000. There are also opportunities for funding from other CERC offices.

E. RESEARCH PROJECT WITH ARMY COASTAL ENGINEERING RESEARCH CENTER FOR A GRAPHICAL USER INTERFACE FOR THE LOGISTICS OVER THE SHORE (LOTS) REAL TIME WAVE FORECASTING SYSTEM

The objective was to develop a prototype GUI for integrated operation of the CERC Real Time Wave Forecasting System. The Principal Investigator for this Project was Mr. M.S. Foster of CAST.

The GUI supported interactive user input of CERC-determined criteria for initialization of the SHALWSV, STWAVE, and SURF models and displaying their outputs. The features included were constant resolution-variable dimension computational grid generation; predefined regions; variable start/end time constraints; boundary conditions; sea state initialization; input files in existing formats; model execution and model run status feedback; horizontal map, sea height/sea state versus time, wave period versus time, and wave direction versus time visual plots; and software hooks for future upgrades.

This $21,000 project was completed on 30 November 1993. System upgrades will be added in FY95 under new funding of $30,000. There are also opportunities for funding from other CERC offices.

F. RESEARCH PROJECT WITH GULF WEATHER CORPORATION UNDER THE SMALL BUSINESS INNOVATIVE RESEARCH PROGRAM FOR A METADATA BASE FOR AUTOMATED OCEANOGRAPHIC IMAGERY INFORMATION

The objective is to develop an innovative solution for a unified information structure for a system of automated information tools and methodology to efficiently provide output to oceanographic and meteorological forecast models. A metadata base that concentrates on the recognition of oceanographic and meteorological systems as observed from various satellite sensor systems may lead to improved forecasts, with commercial applications, particularly when areas are cloud covered. Mr. James H. Corbin of CAST is the Principal Investigator for this Project.

Phase I of this research involved the development of metadata fields using sets of automated information tools. The metadata bases will use existing algorithms for browsing, visualization, and diagnostic analysis. New rules, based on the manual identification/analysis system, will be developed. From the sequential analysis of specific systems, information on past movement, shape, and intensity changes can be shown. From this information, the driving physical

forces affecting these systems can be inferred, providing perhaps a forecasting breakthrough.

Phase I of this project (1 October 1993-31 March 1994) was to identify features that lend themselves to automated analysis, and to make recommendations for development of a complete end-to-end system. This Phase was completed on 31 March 1994 under funding of about $17,000 to CAST, and $38,000 to Gulf Weather.

A Phase II proposal has been submitted to DOD with CAST funding of $331,275 total in FY95 and FY96 ($413,246 to Gulf Weather) which involves the actual development of the system. The Phase I results confirmed that the present manual methodology employed by the Navy for analysis and interpretation of oceanographic and meteorological satellite imagery is being rapidly overwhelmed by the volume, type, sophistication, and increasing requirements for products derived from the imagery. The only practical long-term solution to the problem is the use of automated analysis tools for interpretation or assisting analysts in interpreting satellite imagery.

A number of these tools are now available or being developed. A generic user-friendly metadata database system based on a preliminary object-oriented software system was designed and a portion of the system tested. The proposal for Phase II provides details on the recommended design of the system, and the work required to complete the system.

If Phase II is funded, there will be an opportunity to progress to Phase III. Here the small business is expected to use non-federal capital to pursue the commercial applications of the research.

G. PROJECT WITH ONR FOR RESEARCH EQUIPMENT PROCUREMENT TO SUPPORT NAVY R&D AND OPERATIONAL OCEAN MODELING, TACTICAL OCEANOGRAPHY, AND THE DOD MODELING SIMULATION INITIATIVE

The objective was to acquire state-of-the-art computational equipment to enhance CAST capabilities to support the NOMP Program, and various contracts with NRL, the Naval Oceanography Command, and the Army Corps of Engineers. The Principal Investigator for this Project was Dr. Lanny Yeske of CAST.

Under the Defense Experimental Program to Stimulate Competitive Research (DEPSCoR) Program, CAST was awarded a contract to purchase a SUN SparcServer 1000 system with 187 gigabyte optical library unit and laser printer. This equipment was to significantly improve CAST capabilities to continue to

conduct research and to educate/train scientists and engineers in areas important to national defense.

The prescribed funding of $156,837 has been expended, and the following purchases made:

- Sun SparcServer 1000.
- Hewlett-Packard 187 Gigabyte Optical Library Unit.
- Exabyte 10e 8 mm Tape Drive System.
- 144 Hewlett-Packard 1.3 Gigabyte Optical Platters.
- QMS Model 1725 Laser Printer.
- Corresponding software, maintenance, and licenses as appropriate.

While all the equipment has been received, the Epoch Operating System Software (Solaris 2.x) for the Sun SparcServer 1000 has been delayed in its development until the end of 1994. Accordingly, in the interim, Epoch at no additional cost to the contract, provided cost-reductions in their software that allowed CAST to purchase a Sun SparcServer 2 to make use of the Optical Library Unit. Epoch will also install their current software on this system, and when the Solaris 2.x version is available, Epoch will install it on the SparcServer 1000, also at no additional cost.

The period of performance for this project ended on 30 August 1994, with a final report submitted on 1 September 1994. A follow-on contract is not anticipated.

APPENDIX II

CAST PUBLICATIONS

Dietrich, D.E. (1993). On Modeling Geophysical Flows having low Rossby Numbers. Canadian Journal on Atmosphere-Ocean, 31, 57-71.

Foster, S. and D. Krishnamagaru (1993). Users Manual for the Interactive Data Editing and Analysis System Version 1.0. Mississippi State University Center for Air Sea Technology Technical Note 1-93, Feb 1993, 24 pp.

Dietrich, D.E. (1993). A Numerical Study of Small-Scale Continental Shelf Features and their Interactions with Deep Water Flows. Proceedings of the Society of Industrial and Applied Mathematics Conference on Mathematical and Computational Issues in the Geosciences, Hyatt Regency, Houston, TX, 19-21 April 1993

Dietrich, D.E., D. S. Ko, and L.A. Yeske (1993). On the Application and Evaluation of the Relocatable DieCAST Ocean Circulation Model in Coastal and Semi-Enclosed Seas. Mississippi State University Center for Air Sea Technology Technical Report 93-1, 1 Jul 1993, 79 pp.

Romalewski, R.S. J.H. Hammond, and M.S. Foster (1993). A Wide Area Network for Atmospheric and Oceanographic Simulations. Proceedings 1993 Summer Computer Simulation Conference, Boston, MA, 19-21 July 1993, 5 pp.

Dietrich, D.E. (1993). Shelf Resolving Numerical Study of the Gulf of Mexico. Proceedings 3rd American Society of Civil Engineers International Conference on Estuarine and Coastal Modeling, Hyatt Regency, Oak Brook, IL, 8-10 September 1993.

Foster, M.S. (1993) Editor. Design Documentation and Database Specification for the Naval Interactive Data Analysis System (NIDAS) Version 1.0. Mississippi State University Center for Air Sea Technology Technical Memorandum 1-94, Stennis Space Center, MS, 29 October 1993, 40 pp.

Foster, M.S. (1993) Editor. User's Manual for the Naval Interactive Data Analysis System (NIDAS) Version 1.0. Mississippi State University Center for Air Sea Technology Technical Memorandum 3-94, Stennis Space Center, MS, 29 November 1993, 49 pp.

Yeske, L.A. (1993) Editor. 1993 Student Research Projects, Mississippi State University Center for Air Sea Technology Technical Note 2-94, 31 Dec 93, 23 pp.

Kantha, L.H., P.E. Pontius, and V. Anantharaj (1993). Tides in Marginal, Semi-Enclosed, and Coastal Seas Part I: Sea Surface Height. University of Colorado Department of Aerospace Engineering Sciences Technical Report, 31 Dec 1993, 300 pp.

Dietrich, D.E. (1994a). Numerical Model Reproduces Small-Scale Features of Gulf Circulation. Fortnightly Newsletter Vol. 3, Issue 2, LATEX Data Office, Texas A&M University, 17 January 1994, 2 pp.

Dietrich, D.E., M.J. Bowman, C.A. Lin, and A. Mestas-Nunez (1994). Numerical Studies of Small Island Wakes. Mississippi State University Center for Air Sea Technology Technical Report 94-1, 11 February 1994, 79 pp.

Dietrich, D.E. and C.A. Lin (1994). Numerical Studies of Eddy Shedding in the Gulf of Mexico. Journal of Geophysical Research, 99, C4, 15 April 1994, 7599-7615.

Schatzle F. and J.H. Corbin (1994). A Metadata Database for Automated Oceanographic Imagery. Gulf Weather Corporation and Mississippi State University Center for Air Sea Technology Report FR-N93-002/P1, 29 April 1994, 33 pp.

Dietrich, D.E., A. Mestas-Nunez, C. Lin, and D-S Ko (1994). A High Resolution Numerical Study of the Gulf of Mexico Circulation. Proceedings 1994 American Geophysical Union Ocean Sciences Meeting, Baltimore, MD, 27 May 1994.

Lin, C.A. and D.E. Dietrich (1994). A Numerical Study of Low Reynolds Number Two-Dimensional Convective Adjustment. Geophys. Astrophys. Fluid Dyn., 74, 123-134.

Perrin, P. and F. Petry (1994). Design of an Intelligent Support System for Scientific Databases. Mississippi State University Center for Air Sea Technology Technical Report 94-2, 1 August 1994, 34 pp.

Foster, M. S. (1994) Editor. Design Document for the MOODS Data Management System. Mississippi State University Center for Air Sea Technology Technical Note 94-6, August 1994, 47 pp.

Foster, M. S. (1994) Editor. Design Documentation Manual for the Surface Currents Data Base Management System Version 1.0. Mississippi State University Center for Air Sea Technology Technical Note 94-8, August 1994, 41 pp.

Foster, M. S. (1994) Editor. User's Manual for the MOODS Data Management System Version 1.0. Mississippi State University Center for Air Sea Technology Technical Note 94-5, August 1994, 47 pp.

Foster, M. S. (1994) Editor. User's Manual for the Surface Currents Data Base. Mississippi State University Center for Air Sea Technology Technical Note 94-7, August 1994, 47 pp.

Passi, R.M. and H. Anand (1994). Objective Feature Identification and Tracking: A Review. Mississippi State University Center for Air Sea Technology Technical Report 94-4, 15 September 1994, 45 pp.

Yeske, L.A. and J.H. Corbin (1994). FY93 and FY94 Research Program in Navy Ocean Modeling and Prediction. Mississippi State University Center for Air Sea Technology Technical Report 94-3, 30 September 1994, 70 pp.

Yeske, L.A. (1994) Editor. 1994 Student Research Projects, Mississippi State University Center for Air Sea Technology Technical Note 94-4, 20 September 1994, 45 pp.

Bowman, M.J., D.E. Dietrich, and C.A. Lin (1994). Observations and Modeling of Mesoscale Ocean Circulation Near Small Isolated Islands. Small Island Oceanography, AGU Coastal and Esturarine Studies Series, Edited by George Maul. (In Press.)

Dietrich, D.E. and D-S. Ko (1994). A Semi-Collocated Ocean Model Based on the SOMS Approach. International J. Num. Methods in Fluids (In Press).

Dietrich, D.E., C.A. Lin, A. Mestas-Nunez, and D.-S. Ko (1994). A High Resolution Numerical Study of Gulf of Mexico Fronts and Eddies. To be submitted to Journal of Geophysical Research Special Issue on Gulf of Mexico Eddies. (Under Review.)

Dietrich, D.E. and D.-S. Ko (1994). A Numerical Study of Shelfbreak Effects in the Western Gulf of Mexico. To be submitted to Journal of Geophysical Research Special Issue on Gulf of Mexico Eddies. (Under Review.)

Dietrich, D.E., M.J. Bowman, C.A. Lin, and A. Mestas-Nunez (1994). Numerical Studies of Small Island Wakes. To be submitted to Geophys. Astrophys. Fluid Dynamics. (Under Review.)

Dietrich, D.E. (1994b). Parameter Sensitivity Studies in the Gulf of Mexico. Invited Contribution to Appear in: Coastal Ocean Prediction, C.N.K. Mooers, Editor. CRC Press, Boca Raton, FL. (In Preparation.)

Dietrich, D.E. (1994c). Reynolds Number and Resolution Sensitivity Studies with Gulf of Mexico Eddies. To be submitted to Journal of Geophysical Research. (Under Review.)

CAST PRESENTATIONS AND DEMONSTRATIONS

Corbin, J.H., H. Anand, and R. Krishnamagaru (1992). CAST Technology Support Capabilities. Demonstration/Presentation to Naval Research Laboratory Ocean Dynamics and Prediction Branch, Stennis Space Center, MS, 5 Oct 1992.

Corbin, J.H., H. Anand, and R. Krishnamagaru (1992). CAST Technology Support Capabilities. Demonstration/presentation to EMPRESS Software personnel, Stennis Space Center, MS, 6 Oct 1992.

Corbin, J.H. and R. Krishnamagaru (1992). Use of Relational Database Management in Geophysical Applications. Mississippi State University Department of Computer Science Seminar, Mississippi State, MS, 9 Oct 1992.

Foster, M.S. (1992). Databases in a Network Environment. Meeting of the Next Generation Computer Resources Database Integration Standards Working Group, Orlando, FL, 28 Oct 1992.

Corbin, J.H. (1992). CAST Technology Support Capabilities. Presentation to Cray Research personnel at Supercomputing '92 Conference, Minneapolis, MN 16 Nov 1992.

Corbin, J.H. and H. Anand (1992). CAST Technology Support Capabilities. Demonstration to Empress Software personnel at Supercomputing '92 Conference, Minneapolis, MN, 16 Nov 1992.

Dietrich, D.E. (1992). Recent Applications of the Sandia Ocean Modeling System in the Gulf of Mexico. Sandia National Laboratory Massively Parallel Computer Science Department Seminar, Albuquerque, NM, 11 Dec 1992.

Corbin, J.H. (1993). The CAST Integrated Research Program. Presentation to Oceanographer of the Navy personnel, Stennis Space Center, MS, 6 Jan 1993.

Corbin, J.H. (1993). Data Management and Evaluation for the Ocean Sciences. Coastal Engineering Research Center Seminar, Army Corps of Engineers Waterway Experiment Station Coastal Engineering Research Center, Vicksburg, MS, 12 Jan 1993.

Krishnamagaru, R., H. Anand, and V.G. Anantharaj (1993). EMS - A Modular System for Oceanographic Model Evaluation. Ninth International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology, Anaheim, CA, 17-22 Jan 1993.

Corbin, J.H. (1993) The CAST Integrated Research Program. Presentation to Commander Naval Oceanography Command personnel, Stennis Space Center, MS, 25 Jan 1993.

Dietrich, D.E. (1993). Mathematical Modeling and Data Comparison in the Gulf of Mexico. University of Southern Mississippi Scientific Computing Seminar, Stennis Space Center, MS, 1 Feb 1993.

Corbin, J.H. (1993). CAST Technology Support Applications. Presentation to Planning Systems personnel, Stennis Space Center, MS, 4 Feb 1993.

Corbin, J.H. (1993). The CAST Advanced Development Research Program. Presentation to SPAWARS Code PMO411 personnel, Naval Research Laboratory, Stennis Space Center, MS, 10 Feb 1993.

Dietrich, D.E. (1993). On the Application of the SOMS and DieCAST Ocean Models in the Gulf of Mexico. Mississippi State University Department of Civil Engineering Seminar, Mississippi State, MS, 17 Feb 1993.

Corbin, J.H. (1993). The CAST 6.3 Advanced Development Research Program. Presentation to Navy ASW Environmental Acoustic Support Program Personnel, Office of Naval Research, Arlington, VA, 18 Feb 1993.

Corbin, J.H. (1993). CAST Technology Support Applications. Presentation to Naval Reserve Unit-Houston, Stennis Space Center, MS, 21 Feb 1993.

Corbin, J.H. and V.G. Anantharaj (1993). The CAST Research and Development Program. Presentation to University of Texas Center for High Performance Computing personnel, Texas State Computer Center, Austin, TX, 16 Mar 1993.

Krishnamagaru, R., J.H. Corbin, and H. Anand (1993). An Information Browser for an Environmental Database. The Oceanographic Society Meeting Remote Access Demonstration, Seattle, WA, 13-16 Apr 1993.

Dietrich, D.E. (1993). Parameter Sensitivity Studies of the Gulf of Mexico. Institute of Ocean Sciences Seminar, Victoria, British Columbia, 15 Apr 1993.

Anand, H. (1993). A Tour of Software Packages and Visualization. University of Southern Mississippi Scientific Computing Seminar, Stennis Space Center, MS, 19 Apr 1993.

Foster, M.S. (1993). NEONS at MSU CAST. NEONS User's Group Conference, Naval Postgraduate School, Monterey, CA, 19 Apr 1993.

Corbin, J.H. (1993). CAST Research Support to Navy Ocean Modeling and Prediction. Office of Naval Research Program Review, Naval Research Laboratory, Washington, DC, 20 Apr 1993.

Anand, H. (1993). Good Public Domain Software for Shared Memory Computers and Workstations. University of Southern Mississippi Scientific Computing Seminar, Stennis Space Center, MS, 26 Apr 1993.

Foster, M.S. (1993). Data Management and Evaluation for the Ocean Sciences. American Society of Civil Engineers Annual Meeting, Army Corps of Engineers Waterway Experiment Station, Vicksburg, MS, 3 May 1993.

Dietrich, D.E. (1993). On the Application and Evaluation of the Relocatable DieCAST Ocean Circulation Model in Coastal and Semi-Enclosed Seas, University of Miami Seminar, Miami, FL, 26 May 1993.

Yeske, L.A. (1993). Research at MSU CAST. Mississippi Institutions of Higher Learning Board Member Visitation Meeting, Stennis Space Center, MS, 15 Jun 1993.

Romalewski, R.S. J.H. Hammond, and M.S. Foster (1993). A Wide Area Network for Atmospheric and Oceanographic Simulations. Presentation at 1993 Summer Computer Simulation Conference, Boston, MA, 20-21 July 1993.

Dietrich, D.E. (1993). Shelf Resolving Numerical Study of the Gulf of Mexico. Presentation at 3rd American Society of Civil Engineers International Conference on Estuarine and Coastal Modeling, Hyatt Regency, Oak Brook, IL, 8-10 September 1993.

Dietrich, D.E. (1993). A Numerical Study of Low Reynolds Numbers in Modeling the Gulf of Mexico. Presentation at World Ocean Circulation Experiment Modeling Workshop, Victoria, B.C., 13-17 September 1993.

Corbin, J.H. (1993). Distributed Databases for Tactical Oceanography Wide Area Network, Presentation at 6.2 Tactical Oceanography Review, Naval Research Laboratory, Stennis Space Center, MS, 23-24 September 1993.

Dietrich, D.E. (1993). Numerical Modeling in the Gulf of Mexico. Presentation to Naval Research Laboratory Ocean Dynamics and Prediction Branch, Stennis Space Center, MS, 7 October 1993.

Corbin, J.H. (1993). CAST Applications. Demonstration to Naval Oceanographic Office, NRL, JayCor, and A&T Program Managers, Stennis Space Center, MS, 7 Oct 1993.

Dietrich, D.E. (1993). Early Results from High Resolution Gulf of Mexico Studies, Presentation at Naval Research Laboratory Coastal Modeling Workshop, Naval Postgraduate School, Monterey, CA, 20 October 1993.

Dietrich, D.E. (1993). Numerical Simulation of Warm Core and Secondary Eddies in the Gulf of Mexico, Presentation at Minerals Management Service LATEX Workshop, New Orleans, LA, 28 October 1993.

Corbin, J.H. (1993). CAST Advanced Development Applications. Demonstration to SPAWARS 6.3 Program Managers, Stennis Space Center, MS, 3 November 1993.

Corbin, J.H. (1994). CAST Advanced Development Applications. Demonstration to SPAWARS 6.3 Program Managers, Stennis Space Center, MS. 19 January 1994.

Anand, H. (1994). CAST Applications. Demonstration to Dr. V. Panchang of the University of Maine, Stennis Space Center, MS, 25 January 1994.

Corbin, J.H. (1994). CAST Applications. Demonstration to CAPT David Martin, Director of NAVOCEANO Warfighting Support Center, Dr. Andrew Johnson, Head of NAVOCEANO Ocean Modeling Division, and other NAVOCEANO personnel. Stennis Space Center, MS, 24 February 1994.

Dietrich, D.E. (1994). Vortex Dynamics in Numerically Modeled Flow Around Islands. Presentation at American Geophysical Union/American Society of Limnology and Oceanography Ocean Sciences Meeting, San Diego, CA, 21-25 February 1994 (With C.A. Lin and M.J. Bowman).

Dietrich, D.E. (1994). Observations and Modeling of Mesoscale Ocean Circulation Near a Small Island. Presentation at American Geophysical Union/American Society of Limnology and Oceanography Ocean Sciences Meeting, San Diego, CA, 21-25 February 1994 (With C.A. Lin and M.J. Bowman).

Dietrich, D.E. (1994). Gulf of Mexico Studies With Two Ocean Models. Presentation at American Geophysical Union/American Society of Limnology and Oceanography Ocean Sciences Meeting, San Diego, CA, 21-25 February 1994 (With C.A. Lin, A. Mestas-Nunez, and D.-S. Ko).

Corbin, J.H. (1994). CAST Applications and Capabilities. Demonstration to Dr. Martin Miller, Army Corps of Engineers Coastal Engineering Research Center, and Several Students, Stennis Space Center, MS, 24 February 1994.

Corbin, J.H. (1994). CAST Applications and Capabilities. Demonstration to Ms. Martha Head and other Naval Oceanographic Office Warfare Support Center Personnel, Stennis Space Center, MS, 3 May 1994.

Corbin, J.H. and M.S. Foster (1994). CAST Applications and Capabilities. Demonstration to British Personnel from the Office of the Director, Navy Meteorology and Oceanography, Stennis Space Center, MS, 9/10 May 1994.

Dietrich, D.E. (1994). Numerical Modeling using DieCAST. Presentation to CIMREP (Commander Naval Meteorology and Oceanography Command Interim Model Review and Evaluation Panel), Stennis Space Center, MS, 12 May 1994.

Dietrich, D.E. (1994). High Resolution Coastal Model Studies. Presentation to ONR Navy Ocean Modeling and Prediction Program Manager and ONR Site-Review Team, Stennis Space Center, 16 May 1994.

Moorhead, R.J. (!994). A Unified Air-Sea Visualization System. Presentation to ONR Navy Ocean Modeling and Prediction Program Manager and ONR Site-Review Team, Stennis Space Center, 16 May 1994.

Hodges, J. (19940. Development of an Object-Oriented Geophysical Database System. Presentation to ONR Navy Ocean Modeling and Prediction Program Manager and ONR Site-Review Team, Stennis Space Center, 16 May 1994.

Anantharaj, V (1994). Relocatable Numerical Models of Marginal, Semi-Enclosed, and Coastal Seas. Presentation to ONR Navy Ocean Modeling and Prediction Program Manager and ONR Site-Review Team, Stennis Space Center, 16 May 1994.

Chu, P. and H. Anand (1994). Semi-Enclosed and Coastal Ocean/Atmosphere Simulation Technology. Presentation to ONR Navy Ocean Modeling and Prediction Program Manager and ONR Site-Review Team, Stennis Space Center, 16 May 1994.

Foster, M.S. and V. Anantharaj (1994). MSU CAST Participation in DAMEE North Atlantic Basin. Presentation to ONR Navy Ocean Modeling and Prediction Program Manager and ONR Site-Review Team, Stennis Space Center, 16 May 1994.

Corbin, J.H. (1994). CAST Software Applications. Demonstration to Mr. J. Monday, A&T, Inc., Monterey, CA, Stennis Space Center, MS, 27 June 1994.

Corbin, J.H. (1994). Software Transitions to NAVOCEANO and TESS. Presentation to ONR Navy Ocean Modeling and Prediction Program Manager and ONR Site-Review Team, Stennis Space Center, 16 May 1994

Corbin, J.H. and F. Schatzle (1994). Metadata Database for Automated Oceanographic Imagery. Presented to Rear Admiral John Chubb, Commander Naval Meteorology and Oceanography Command and Staff, Stennis Space Center, MS, 23 May 1994.

Dietrich, D.E., A. Mestas-Nunez, C. Lin, and D-S Ko (1994). A High Resolution Numerical Study of the Gulf of Mexico Circulation. Presentation at 1994 American Geophysical Union Ocean Sciences Meeting, Baltimore, MD, 27 May 1994.

Corbin, J.H. (1994). Software Transitions to FNMOC, NRL, and TESS. Presentation at Fleet Numerical Meteorology and Oceanography Center, Monterey, CA, 9 June 1994.

Corbin, J.H. (1994). CAST Research Program. Presentation to MSU Research Directors Council, Mississippi State, MS, 17 June 1994.

Corbin, J.H. and F. Schatzle (1994). Research under the DoD Small Business Innovative Research Program. Presentation to SPAWARS Personnel, Arlington, VA, 23 June 1994.

Corbin, J.H. and J. Radvanyi (1994). Proposed Workshop on Dumped Nuclear Waste in the Sea of Japan and North Pacific Ocean. Presentation to U.S. Geological Survey Personnel, Reston, VA, 22 June 1994.

Yeske, L.A. (1994). The CAST Research Program. Presentation at EPA Gulf of Mexico Program Workshop, Stennis Space Center, 23 June 1994.

Foster, M.S. (1994). CAST Software Applications. Demonstration to Center for Earth Sciences, Ann Arbor, MI, Stennis Space Center, MS, 23 June 1994.

Foster, M.S. (1994). CAST Software Applications. Demonstration to Naval Oceanographic Office Personnel, Stennis Space Center, MS, 24 June 1994.

Foster, M.S. (1994). TOWAN Data Extraction. Demonstration to Tactical Oceanography Simulation Laboratory Personnel, Stennis Space Center, MS, 28 June 1994.

Corbin, J.H. (1994). CAST FY95 Research Program and Issues. Presentation to MSU Vice President for Research, MSU Director of Centers and Institutes, and MSU Director of Sponsored Programs Administration, Stennis Space Center, MS, 14 July 1994.

Corbin J.H. (1994). CAST Software Applications. Demonstration to Ms. Charlotte Morris of NASA Education Programs, Stennis Space Center, MS, 19 July 1994.

Corbin, J.H. (1994). CAST Software Applications. Demonstration to NASA Teachers Resource Center Personnel, Stennis Space Center, MS, 20 July 1994.

Krishnamagaru, R. (1994). Graphics and Visualization Transitions to the Tactical Environmental Support System. Demonstration to Tactical Oceanography Simulation Laboratory Personnel, Stennis Space Center, MS, 26 July 1994.

Corbin, J.H. (1994). Graphics and Visualization Transitions to the Tactical Environmental Support System. Demonstration to Commanding Officer, Fleet Numerical Meteorology and Oceanography Center, Stennis Space Center, MS, 29 July 1994.

Corbin, J.H. (1994). FY95 Planned Research in Software Transitions to NAVOCEANO and TESS. Presentation to Dr. Edward Harrison, SPAWARS; CDR Dave Markham, SPAWARS; and Mr. Ray Godin of OCEANAV, Stennis Space Center, MS, 3 August 1994.

Corbin, J.H. (1994). CAST Software Applications. Demonstration to Executive Officer and Technical Director, FNMOC, and Deputy Chief of Naval Research, Stennis Space Center, MS, 15 Aug 1994.

Krishnamagaru, R. and A. Matiyevsky (1994). CAST Software Applications. Demonstration to Captain Rick Hillyer of SPAWARS, Stennis Space Center, MS, 16 Aug 1994.

Corbin, J.H. (1994). CAST Software Applications. Demonstration to Mr. Robert Palmer, MSU OSPA Industrial Contracts, Stennis Space Center, MS, 16 Aug 1994.

Zhu, Z. and V. Anantharaj (1994). ENVIS (Environmental Visualization) Software Development. Demonstration to CAST personnel, Stennis Space Center, MS 23 Aug 1994.

SEMINARS SPONSORED BY CAST

Name/Institution	Title	Date
Dr. Patrick Roache Ecodynamics Research Albuquerque, NM	Marching Methods and Domain Decomposition	26 Oct 92
Dr. Robert Bernard Waterways Exp Station Vicksburg, MS	Three-Dimensional Incompressible Flow Calculations with MacCormack's Method	26 Oct 92
Dr. Kang-Ren Jin Engineering Res Center Mississippi State Univ.	Structured and Unstructured Grid Applications to Numerical Models	26 Oct 92
Dr. David E. Dietrich CAST Mississippi State Univ.	Parameter Sensitivity Studies in Ocean Models	26 Oct 92
Dr. Donna Reese Computer Science Dept Mississippi State Univ.	Introduction to Parallel Processing Considerations for Computational Engineering Applications	2 Dec 92
Mr. Alberto Mestas-Nunez College of Oceanic Sci. Oregon State University Corvallis, OR	An Evaluation of ECMWF-Based Climatological Wind Stress Fields	20 May 93
Mr. Patrick Perrin Dept of Computer Science Tulane University New Orleans, LA	Knowledge Discovery and Information Retrieval in Large Numerical Databases-An Application to Ocean Modeling	15 Aug 93
Mr. Zhifan Zhu Engineering Res Center Mississippi State Univ.	Enhancing the Visualization Capabilities of the CAST Model Evaluation System	15 Aug 93

Mr. Shekar Ramanathan Dept of Computer Science Mississippi State University	Object-Oriented Access to Geophysical Data	15 Aug 93
Ms. Dongmei Wu Dept of Computer Science Mississippi State Univ.	A Window-Based Intelligent Interface for Defining Descriptive Data in the NEONS Database	15 Aug 93
Mr. Puli Rangabashyan Dept of Computer Science Mississippi State Univ.	Enhancing CMES Data Visualization Capabilities, the Addition of Database to BROWSER, and NIDAS Support	15 Aug 93
Mr. Srinivas Bontu Cooperative Educ Program Mississippi State Univ.	Development of a Network Data BROWSER and the Evaluation of Two Networking Paradigms	15 Aug 93
Mr. L. Ramakrishna Cooperative Educ Program Mississippi State Univ.	Graphics Support for Ocean Models, a 2D CAST Ocean Visualization System, and Integration of OVIRT	15 Aug 93
Mr. Mark Henry Cooperative Educ Program Mississippi State Univ.	A Relocatable 2D Tidal Model, a Color Palette for Volume Rendering, and MOODS DBMS	15 Aug 93
Mr. Atchuta Bontu Department of Engineering Louisiana Tech University	Client/Server Model to Access a Database Across the Network	15 Aug 93
Ms. LeAna Dusang College of Science & Tech Univ. of S. Mississippi	Database Applications and Their Documentation	15 Aug 93
Mr. Clifton Abbott Cooperative Educ Program Mississippi State Univ.	Tactical Oceanography Wide Area Network, Network Data BROWSER, and Database Duplicate Identifier	15 Aug 93
Dr. Lianggui Chen Scripps Institution of Oceanography LaJolla, CA	Intergyre Water Exchange of Combined Wind and Buoyancy Forcing	26 Oct 93

Dr. Malcolm Bowman Marine Sciences Center State University of New York	Observations and Modeling of Mesoscale Ocean Circulation Near a Small Island	10 Dec 93

WORKSHOPS AND MEETINGS SPONSORED BY CAST

Navy Environmental Operational Nowcast System Applied to the Tactical Oceanography Wide Area Network. User Course for Naval Research Laboratory Personnel, Stennis Space Center, MS, 20 Jan 1993.

Navy Environmental Operational Nowcast System Applied to the Tactical Oceanography Wide Area Network. User Course for Naval Research Laboratory Personnel, Stennis Space Center, MS, 9 Mar 1993.

Navy Environmental Operational Nowcast System Applied to the Tactical Oceanography Wide Area Network. User Course for Naval Research Laboratory Personnel, Stennis Space Center, MS, 8 Jun 1993.

Graduate and Undergraduate Student Research Project Reports, CAST Summer Workshop, Stennis Space Center, MS, 15 August 1993.

OTHER WORKSHOPS AND MEETINGS ATTENDED BY CAST

Name	Title	Dates/Location
H. Anand V. Anantharaj C. Cesario J.H. Corbin D. Dietrich D. Earwood M.S. Foster D. Goff D.Krishnamagaru R. Krishnamagaru L. Yeske	Mississippi State University ERC Annual Industrial Meeting	6-9 October 1992 Mississippi State, MS
V. Anantharaj	Visualization '92 Conference	15-23 October 1992 Boston, MA
M.S. Foster	Next Generation Computer Resources Database Integration Standards Working Group	28 October 1992 Orlando, FL
H. Anand J.H. Corbin	Supercomputing '92 Conference	16-20 Nov 1992 Minneapolis, MN
E. Lott	MSU Sponsored Research Workshop	23-25 Nov 1992 Mississippi State, MS
V. Anantharaj	American Meteorological Society 73rd Annual Meeting	17-22 January 1993 Los Angeles, CA
H. Anand V. Anantharaj R. Krishnamagaru	Ninth International Conference on Interactive Information Processing Systems for Meteorology, Oceanography, and Hydrology	17-22 January 1993 Anaheim, CA
J.H. Corbin	Office of Naval Research Meeting on 6.3 Research	17-18 February 1993 Washington, DC
D. Krishnamagaru	Software Development 93 Conference	22-26 February 1993 San Jose, CA

V. Anantharaj M.S. Foster	Commercial Applications of Remote Sensing Technology for the Environment Workshop	2-4 March 1993 New Orleans, LA
J.H. Corbin L.A. Yeske	National Science Foundation Workshop "The Times They are a Changin"	10-12 March 1993 Jackson, MS
C. Cesario	EMPRESS User Group Meeting	15-16 March 1993 San Francisco, CA
J.H. Corbin D. Dietrich L. Yeske	Office of Naval Research Coastal Ocean Modeling Workshop	23-24 March 1993 Long Beach, MS
H. Anand J. H. Corbin D.E. Dietrich L.A. Yeske	Third Scientific Meeting of The Oceanographic Society	13-16 April 1993 Seattle, WA
M.S. Foster	NEONS User's Group Conference	19 April 1993 Monterey, CA
J.H. Corbin L.A. Yeske	Office of Naval Research Program Review	19-20 April 1993 Washington, DC
D.E. Dietrich	Society of Industrial and Applied Mathematics Conference on Mathematical and Computational Issues in the Geosciences	19-21 April 1993 Houston, TX
M.S. Foster	American Society of Civil Engineers - Mississippi Chapter Annual Meeting	3 May 1993 Vicksburg, MS
V. Das D. Krishnamagaru R. Krishnamagaru	ORACLE Relational Database Management Training Course	10 May 1993 Stennis Space Center, MS
D.E. Dietrich	Gordon Research Conference on Coastal Ocean Modeling	13-18 June 1993 Boston, MA

J.H. Corbin M.S. Foster L.A. Yeske	Proposals to Transfer CAST Applications to the Medical Industry in Collaboration with Houston Advanced Research Center	27-30 June 1993 Woodlands, TX
J.H. Corbin D. Krishnamagaru Y. Lau	ACM Siggraph '93 Meeting (Association of Computer Machinery Special Interest Group on Graphics)	2-6 August 1993 Los Angeles, CA
M.S. Foster	University of Texas/IEEE Workshop on Metadata Access of Stored Informational Entities	26-27 August 1993 Austin, TX
J.H. Corbin M.S. Foster D. Krishnamagaru L.A. Yeske	Naval Oceanographic Office Demonstration of NAVOCEANO Interactive Data Analysis System (NIDAS) developed by CAST	1 September 1993 Stennis Space Ctr, MS
D.E. Dietrich	Third International Conference Estuarine and Coastal Modeling	8-10 September 1993 Oak Brook, IL
D.E. Dietrich	World Ocean Circulation Experiment Progress Meeting	13-17 Sept 1993 Victoria, B.C.
J.H. Corbin A. Mestas-Nunez	Navy Ocean Modeling and Prediction Meeting on Present/ Future Data Assimilation and Model Evaluation Experiments	20-21 Sept 1993 Princeton, NJ
E. Lott	Human Resource Management Workshop	24 Sept 1993 Mississippi State, MS
J.H. Corbin	Data Management Workshop The Oceanography Society	28-30 Sept 1993 East Greenwich, RI
D.E. Dietrich	Naval Research Laboratory Coastal Modeling Workshop	14-15 Oct 1993 Monterey, CA
D.E. Dietrich A. Mestas-Nunez	Minerals Management Service LATEX III Progress Meeting	18 October 1993 New Orleans, LA

J.H. Corbin L.A. Yeske	Mississippi State University Cooperative Education Days	19-20 Oct 1993 Mississippi State, MS
J.H. Corbin L.A. Yeske Susan Bridges	Naval Oceanographic Office Demonstration of Warfighting Support Center Capabilities	28 Oct 1993 Stennis Space Ctr, MS
H. Anand	IEEE Supercomputing '93 Conference	15-19 Nov 1993 Portland, OR
D. Krishnamagaru Vishnu Das	15th Annual Interservice/Industry Training Systems and Education Conference	29 Nov-3 Dec 1993 Orlando, FL
E. Lott	Research Administration Workshop	21 Jan 1994 Mississippi State, MS
J.H. Corbin M.S. Foster	Conference of the American Meteorological Society	24-28 Jan 1994 Nashville, TN
D. Dietrich	AGU/ASLO Ocean Sciences Meeting	21-25 Feb 1994 San Diego, CA
A. Mestas-Nunez	Gulf of Mexico Physical Oceanography Workshop	5-7 Apr 1994 Tallahassee, FL
D. Dietrich	Research Collaborations with Dr. Malcolm Bowman at University of Otago	14-28 Mar 1994 Dunedin, New Zealand
D. Dietrich	Research Collaborations with Dr. Brian Sanderson, Bureau of Meteorology Research Center	1-11 Apr 1994 Melbourne, Australia
M.S. Foster	NEONS User's Conference Sponsored by NRL-Monterey	18-22 Apr 1994 Monterey, CA
D. Dietrich	Research Collaborations with Dr. Keith Thompson at Dalhousie University	16-22 Apr 1994 Halifax, Nova Scotia

D. Dietrich	Research Collaborations with Dr. Richard Greatbatch, Memorial University	22-30 Apr 1994 St. Johns, Newfoundland
D. Dietrich	Research Collaborations with Dr. Charles Lin of McGill University and CERCA	22-30 Apr 1994 Montreal, Canada
J. Corbin D.E. Dietrich H. Anand	Meeting of the Commander Naval Meteorology and Oceanography Command Interim Model Review and Evaluation Panel	12-13 May 1994 Stennis Space Ctr, MS
J.H. Corbin Entire MSU Staff R. Moorhead J. Hodges S. Bridges	Office of Naval Research Program Site Review	16-17 May 1994 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske	Dedication Ceremony for Mississippi Enterprise for Technology	25 May 1994 Stennis Space Ctr, MS
D. Dietrich	1994 American Geophysical Union Ocean Sciences Meeting	23-27 May 1994 Baltimore, MD
J.H. Corbin R. Krishnamagaru	Meeting with Naval Research Laboratory and FNMOC Personnel in Software Transitions to the Tactical Environmental Support System	30 May - 1 June 1994 Monterey, CA
J.H. Corbin R. Krishnamagaru V. Anantharaj	Planning Meeting on the Data Assimilation and Model Evaluation Experiment for the North Atlantic Basin	2-3 June 1994 Monterey, CA
M.S. Foster	Meeting with Applied Physics Laboratory University of Texas Personnel on the Battle Force Tactical Training Project	31 May - 3 June 1994 Austin, TX

V. Anantharaj R. Krishnamagaru A. Matiyevsky	Training Course at MSU-NSF Engineering Research Center	25-27 May 1994 Mississippi State, MS
J.H. Corbin L.A. Yeske	MSU Research Director Council Meeting	17 June 1994 Mississippi State, MS
L. Yeske M.S. Foster	Environmental Protection Agency Workshop on Protection of the Gulf of Mexico Ecosystem	23 June 1994 Stennis Space Ctr, MS
J.H. Corbin Entire MSU Staff R. Moorhead S. Bridges	Management Review of CAST by MSU Vice President for Research, Director Centers and Institutes, and Director Sponsored Programs Administration	14 July 1994 Stennis Space Ctr, MS
J.H. Corbin L.A. Yeske	Meeting on Japan-Russia-U.S. Study Group on Dumped Nuclear Waste in the Sea of Japan	23 August 1994 Stennis Space Ctr, MS
J.H. Corbin R. Krishnamagaru C. Cesario	Meetings with NRL on Tactical Oceanography Simulation Laboratory	6-7 September 1994 Stennis Space Ctr, MS
R.M. Moorhead	REINAS Review by ONR	13-14 September 1994 Monterey, CA
J.H. Corbin R. Krishnamagaru	Meeting on Software Transitions to FNMOC and TESS	17-25 September 1994 Monterey,CA

PROFESSIONAL AWARDS TO CAST PERSONNEL

To J.H. Corbin, Top Ten Principal Investigators/Outstanding Faculty Member at Mississippi State University, 7 Sept 1993.

To J.H. Corbin, Nominated for Mississippi State University Alumni Association Outstanding Researcher Award, 11 Feb 1994

CAST PARTICIPATION IN INTERDISCIPLINARY ACTIVITIES

The MSU Cooperative Education Program. CAST was the only MSU organization that participated as an employer in MSU Interview Days. CAST employed six MSU Cooperative Education student (Mr. Srinivas Bontu, Mr. Lakaragu Ramakrishna, Mr. Mark Henry, Mr. Clifton Abbott, Mr. Puli Rangabashyan, and Mr. Owen Lagarde) during this two year period.

The MSU Engineering Research Center (ERC) and College of Engineering. A Memorandum of Understanding was used for joint research effort in scientific visualization enhancements with CAST involving Dr. Robert Moorehead and Mr. Zhifan Zhu, an ERC Ph.D. student.

The MSU Department of Computer Science. A Memorandum of Understanding was used for a joint research effort on object-oriented designs for databases with CAST involving Dr. Julia Hodges; Dr. Susan Bridges; Mr. Chandrashekar Ramanathan, a Ph.D. student; Mr. Sridar Koduri, a graduate student; and Ms. Dongmei Wu, a graduate student.

The MSU Center for International Security and Strategic Studies and the MSU Water Resources Institute. Here CAST worked with these activities in a proposed workshop on NAFTA and Environmental Cooperation in the Gulf of Mexico Region, under sponsorship of the Environmental Protection Agency. CAST also worked with Dr. Radvanyi in a workshop on "Japan-Russia-United States Study Group on Dumped Nuclear Waste in the Sea of Japan, Sea of Okhotsk, and North Pacific Ocean," which has been funded.

The MSU Scientific and Technical Research Center. Here CAST worked closely with Dr. Roy Crochet in the coordination of joint MSU activities at the Stennis Space Center.

The MSU Research Director's Council. The CAST Director was a member of this council and met periodically with them.

The Mississippi Research Consortium. This interdisciplinary interaction involved the awarding of three contracts to CAST, two from the Naval Oceanographic Office and one from the Naval Research Laboratory, that were issued as NASA delivery orders through the Consortium.

University of Southern Mississippi Center for Ocean and Atmospheric Modeling. CAST, through its ONR research grant, provided technology support to USM modeling efforts.

University of Southern Mississippi College of Science and Technology. CAST also employed USM graduate student Ms. LeAna Dusang to assist in database administration and software engineering.

University of Southern Mississippi Scientific Computing Department. CAST, through its ONR research grant, worked with Dr. Louise Perkins and Ms. Hollie Molyneux, a graduate student in a joint research effort to test and evaluate the CAST Model Evaluation System.

University of Southern Mississippi Cooperative Education Program. CAST employed Mr. Michael Baer and Mr. Mickey Barton, USM graduate students, through this program.

Tulane University Department of Computer Science. CAST sponsored Dr. Fred Petry and Mr. Patrick Perrin, a Ph.D. graduate student in a joint research effort in applying knowledge discovery techniques to databases.

Harvard University. CAST had a collaborative effort (no funding is exchanged) with Dr. Allan Robinson to transition the CAST Model Evaluation System to Harvard for use with the Harvard ocean model.

Houston Advanced Research Center (HARC). CAST worked with Drs. Andrew Blanchard and Michael Stanford to transfer CAST air-sea applications to the medical and health care industry.

University of Colorado. CAST had a collaborative effort (no funding is exchanged) with Dr. Lakshmi Kantha to transition the CAST Model Evaluation System to Colorado for use with his tidal and ocean circulation models.

Louisiana Technological University. CAST employed graduate student Mr. Atchuta Bontu to assist in data browser applications.

Oregon State University. CAST employed graduate student Mr. Alberto Mestas-Nunez to assist in ocean modeling applications.

Brandeis University. CAST employed undergraduate student Mr. Arun Sridharan to assist in software engineering applications.

Gulf Weather Corporation. CAST worked with this company in completing Phase I of a Department of Defense contract under the Small Business Innovative Research Program, and in submitting a Phase II proposal for a Meta-Database for Ocean Imagery.

Naval Postgraduate School. CAST planned to work with Dr. Peter Chu and graduate student on circulation and diffusion studies in the South China Sea.

Naval Research Laboratory-Stennis Space Center, MS. CAST worked with Dr. Paul Martin in using DieCAST to model the Straits of Sicily, with Dr. Harley Hurlburt in coupling the DieCAST Gulf of Mexico model with the Naval Research Laboratory high resolution North Atlantic model, and with Dr. Steve Piacsek in using DieCAST to model the Persian Gulf and in parallelizing DieCAST for MPP applications.

Naval Research Laboratory-Monterey, CA. CAST worked with Drs. Ted Tsui and Gary Love in the transition of CAST software to the Navy's Tactical Environmental Support System.

Ensemble Systems. CAST employed Mr. Andrew Jurkevics as a consultant to assist in the design and modification of the Navy Environmental Operational Nowcasting System.

Planning Systems, Inc. CAST worked with this company in preparing a five-year proposal to support the Naval Research Laboratory Environmental Acoustics Program. This contract was awarded to PSI in August 1994 and CAST is a subcontractor in this effort.

The Oceanography Society. The Third Bi-Annual Meeting of this Society was held in Seattle in April 1993. MSU CAST became the first university to exhibit its research for this group. We also participated in a poster session with a real-time demonstration.

The International Science and Engineering Fair was held at the Mississippi Coast Coliseum in Biloxi during the week of 10 May 1993. Three CAST researchers served as judges on behalf of Sigma Xi.

The Electric Corporation of New Zealand. CAST research Dr. David Dietrich serves as a consultant to this corporation and uses the DieCAST model in environmental impact studies of hydro-electric power plant effects in the Doubtful Sound region.

CAST PROPOSALS SUBMITTED AND CONTRACTS AWARDED

	To	Title	Submitted	Amount Requested	Amount Awarded
a.	Office of Naval Research Arlington, VA	PI: J.H. Corbin Navy Ocean Modeling and Prediction Program	17 Jul 92	$2,938,480	$2,833,725

b.	Naval Oceanographic Office Stennis Space Center, MS	PI: J.H. Corbin Master Oceanographic Observations Dataset Migration	18 Aug 92	191,726	190,500
c.	Naval Research Laboratory Stennis Space Center, MS	PI: J.H. Corbin Transition of CAST Model Evaluation System	1 Sep 92	9,922	9,443
d.	Naval Research Laboratory Stennis Space Center, MS	PI: J.H. Corbin Tactical Oceanography Wide Area Network (TOWAN)	8 Sep 92	975,590	625,000
e.	Naval Research Laboratory Stennis Space Center, MS	PI: J.H. Corbin TOWAN Contract Options	8 Sep 92	202,967	Not Awarded
f.	National Science Foundation Washington, DC	PI: J.H. Corbin Development of Ocean Database Tools	14 Sep 92	292,134	Not Awarded
g.	National Science Foundation Washington, DC	PI: D.E. Dietrich Changes in Gulf of Mexico through Data and Models	23 Oct 92	109,318	Not Awarded
h.	Department of Defense Small Business Innovative Research Program Stennis Space Center, MS	PI: V. Anantharaj Metadata Base for Automated Oceanographic Imagery Information	12 Jan 93	53,544	53,544 27 Sep 93
i.	Department of Defense Washington, DC	PI: M.S. Foster Graduate Student Support for TOWAN	17 Mar 93	80,195	Not Awarded to CAST
j.	Department of Defense Washington, DC	PI: D.E. Dietrich Graduate Student Support for Navy Ocean Modeling	17 Mar 93	80,195	Not Awarded to CAST
k.	Defense Modeling and Simulation Office Washington, DC	PI: J.H. Corbin TOWAN Extension for Tri-Service Applications	18 Mar 93	502,000	Not Awarded to CAST
l.	Army Research Office Research Triangle Park, NC Office of Naval Research Arlington, VA	PI: J.H. Corbin Research Equipment for Navy Ocean Modeling under DEPSCOR Program	25 Mar 93	156,837	$156,837 1 Sep 93
m.	Naval Oceanographic Office Stennis Space Center, MS	PI: D. Krishnamagaru Develop Interactive Data Analysis System	25 Mar 93	196,855	199,000 1 Apr 93
n.	Army Coastal Engineering Research Center Vicksburg, MS	PI: J.H. Corbin Develop Graphical User Interface for Wave Model	21 May 93	21,000	21,000 1 Jul 93
o.	National Institute of Health via the Houston Advanced Research Center (HARC) The Woodlands, TX	PI: J.H. Corbin High Performance Computing Applied to an Augmented Reality Surgical Workstation	1 Jul 93	530,177	Not Awarded to HARC

p.	National Institute of Health via the Houston Advanced Research Center (HARC) The Woodlands, TX	PI: J.H. Corbin High Performance Relational Database for Medical Information Archiving	1 Jul 93	592,975	Not Awarded to HARC
q.	NASA via the University of Colorado Boulder, CO	PI: V. Anantharaj Altimetric Data Archival and Analysis System	9 Jul 93	271,127	Not Awarded to Univ of Colorado
r.	ARPA Technology Reinvestment Program via the Houston Advanced Research Center (HARC) The Woodlands, TX	PI: J.H. Corbin Three-Dimensional Virtual Reality for Battlefield Remote Diagnosis and Medical Training	16 Jul 93	704,280	Not Awarded to HARC
s.	ARPA Technology Reinvestment Program via the Houston Advanced Research Center (HARC) The Woodlands, TX	PI: J.H. Corbin High Performance Relational Database for Medical Image and Records Archiving	16 Jul 93	782,205	Not Awarded to HARC
t.	Army Coastal Engineering Research Center, Vicksburg via NSF and MSU ERC	PI: J.H. Corbin Develop Wave Forecasting Graphical User Interface	27 Jul 93	19,908	19,908 1 Oct 93
u.	Army Coastal Engineering Research Center Vicksburg, MS	PI: J.H. Corbin Develop Graphical User Interface to Engineering Data Retrieval System	2 Aug 93	23,835	23,835 1 Oct 93
v.	NASA Experimental Program to Stimulate Competitive Research (EPSCOR) Washington, DC	PI: H. Anand Graphics/Visualization-CAST Collaborating with MSU Department of Computer Science	27 Aug 93	$308,321	Not Awarded to MSU CS
w.	Naval Research Laboratory Code 3250, Bldg 1007 Stennis Space Center, MS	PI: J.H. Corbin Development of a Prototype Environmental Server for Oceanographic and Met Data	12 Oct 93	$443,925	Not Awarded to NRL or CAST
x.	Naval Research Laboratory Code 3250, Bldg 1007 Stennis Space Center, MS	PI: J.H. Corbin Tactical Oceanography Wide Area Network Support	4 Jan 94	$472,413	92,317 9 May 94
y.	Army Research Projects Agency - Attn: DEPSCoR Arlington, VA	PI: D. Dietrich A Study of Island Wake Flows in the East China Sea	14 Jan 94	$761,056	Not Awarded to CAST
z.	Office of Naval Research Physical Oceanography Div Arlington, VA (One Planning Letter)	PI: D. Dietrich High Resolution Coastal Model Studies in the East China Sea and the Sea of Okhotsk	28 Feb 94	$353,283 (One Year)	Not Awarded to CAST

aa.	Office of Naval Research NOMP (Code 1242) Arlington, VA (17 Planning Letters)	PI: Various Scientific and Technical Support for Navy Ocean Modeling and Prediction Program	16 Mar 94	$3,428,000 (One Year)	Eight proposal submitted as r-y
ab.	Office of Naval Research Coastal Oceanography Div Arlington, VA (One Planning Letter)	PI: L.Kantha/V. Anantharaj Relocatable Numerical Models of Marginal, Semi-Enclosed, and Coastal Seas	18 Mar 94	$210,877 (One Year)	Not awarded to CAST or UC
ac.	Army Coastal Engineering Research Center, Vicksburg via NRL TOWAN	PI: J.H. Corbin Upgrade Graphical User Interface Joint Logistics Over the Shore Real Time Wave Forecast System	23 Mar 94	$30,057	$30,057 29 Jul 93
ad.	Army Coastal Engineering Research Center, Vicksburg via NRL TOWAN	PI: J.H. Corbin Platform Transfer and Upgrade of Coastal Data Retrieval System	23 Mar 94	22,098	Pending
ae.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: D.Dietrich and A. Mestas-Nunez High Resolution Coastal Model Studies	22 Apr 94	612,943	$400,000 17 May 94
af.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: J.H. Corbin, R. Moorhead and B. Hamann: A Unified Air-Sea Visualization System	26 Apr 94	$456,606	$456,606 17 May 94
ag.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: R. Krishnamagaru, J. Hodges, and S. Bridges Development of an Object-Oriented Database System	26 Apr 94	375,151	Not awarded to CAST
ah.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: H. Anand and R. Passi Semi-Enclosed and Coastal Ocean/Atmosphere Simulation Technology	26 Apr 94	93,533	Not awarded to CAST
ai.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: H. Anand and P. Chu Circulation and Diffusion Studies in the South China Sea	26 Apr 94	226,794	Not awarded to CAST
aj.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: V. Anantharaj and L. Kantha, Relocatable Numerical Models of Marginal, Semi-Enclosed, and Coastal Seas	26 Apr 94	332,129	$272,000 17 May 94
ak.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PIs: V. Anantharaj and M. Foster, MSU CAST Participation in DAMEE North Atlantic Basin	26 Apr 94	423,590	$120,000 17 May 94

al.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	PI: J. Corbin Software Transitions to NAVOCEANO and TESS	26 Apr 94	652,544	$500,000 17 May 94
am.	Naval Research Laboratory Environmental Acoustics via Planning Systems, Inc. Slidell, LA	PI: J. Corbin Environmental Acoustics Support - CAST is a Subcontractor to PSI	16 May 94	134,495	$134,495 15 Aug 94
an.	DOD Small Business Innovative Research Program via Gulf Weather Corporation Stennis Space Center, MS	PI: V. Anantharaj Metadata Base for Automated Oceanographic Imagery Information Phase II	16 May 94	331,275	Pending
ao.	Naval Oceanographic Office Code DOST Stennis Space Center, MS	PI: D. Krishnamagaru Navy Interactive Data Analysis System Development-Phase II	3 June 94	29,500	$29,500 17 June 94
ap.	Global Programs National Oceanic and Atmospheric Administration Silver Springs, MD (Planning Letter)	PI: D. Dietrich Decadal/Century Modes of Atlantic Climate Variability	3 June 94	300,000	Not Awarded to CAST
aq.	Global Programs National Oceanic and Atmospheric Administration Silver Springs, MD (Planning Letter)	PI: D. Dietrich North Atlantic Ocean Climate Parameter Sensitivity Studies	10 June 94	292,500	Not Awarded to CAST
ar.	Office of Naval Research Navy Ocean Modeling and Prediction Program Arlington, VA	Co-PI's: R. Krishnamagaru, J. Hodges, and S. Bridges Development of an Object-Oriented Database System	14 July 94	$415,796	Pending
as.	Naval Oceanographic Office Code DOST Stennis Space Center, MS	PI: R. Krishnamagaru Navy Interactive Data Analysis System Development--Phase II	13 June 1994	$99,100	$99,100 30 Aug 94
at.	Department of Defense Washington, DC (AASERT Program)	PI: R. Krishnamagaru Graduate Student Support for NIDAS	25 Aug 94	$171,717	Pending
au.	Department of Defense Washington, DC (AASERT Program)	PI: J. Corbin Graduate Student Support for Software Transitions to the Operational Navy	27 Sept 94	$107,748	Pending

ACKNOWLEDGEMENTS

This research was supported by the Office of Naval Research's Navy Ocean Modeling and Prediction Program under Research Grant N00014-92-J-4109 with Mississippi State University. We greatly appreciate the opportunity afforded to us under this Research Grant, and hope that you are pleased with our performance.

We would also like to thank the scientific, technical, and support personnel (permanent, research affiliates, students, consultants, and subcontractors) who were directly funded by CAST through this Research Grant for their superb performance. These individuals included:

Permanent MSU CAST Personnel

Dr. Harsh Anand
Mr. Valentine Anantharaj
Ms. Cheryl Cesario
Mr. James Corbin
Mr. Vishnumohan Das
Dr. David Dietrich
Mr. Darrell Earwood
Mr. Steve Foster
Mr. Donald Goff
Mr. Dharmesh Krishnamagaru
Mr. Ramesh Krishnamagaru
Ms. Yee Lau
Ms. Evelyn Lott
Mr. Alexander Matiyevsky
Ms. Carolyn Michael
Mr. Christopher Vosbein
Ms. Midge Wilson
Dr. Lanny Yeske

Research Affiliates

Dr. Susan Bridges	Mississippi State University
Dr. Julia Hodges	Mississippi State University
Dr. Robert Moorhead	Mississippi State University
Dr. Frederick Petry	Tulane University

Students

Mr. Clifton Abbott	Mississippi State University
Mr. Michael Baer	University of S. Mississippi
Mr. Mickey Barton	University of S. Mississippi
Mr. Latavious Bell	Mississippi State University
Mr. Atchuta Bontu	Louisiana Tech University
Mr. Srinivas Bontu	Mississippi State University
Mr. Marshall Brown	University of New Orleans
Ms. LeAna Dusang	University of S. Mississippi
Mr. Mark Henry	Mississippi State University
Mr. Sridhar Koduri	Mississippi State University

Mr. Owen Lagarde	Mississippi State University
Ms. Hollie Molyneux	University of S. Mississippi
Mr. Alberto Mestas-Nunez	Oregon State University
Mr. Steven Payne	University of S.Mississippi
Mr. Patrick Perrin	Tulane University
Mr. Lakaraju Ramakrishna	Mississippi State University
Mr. Chandrashekar Ramanathan	Mississippi State University
Mr. Puli Rangabashyan	Mississippi State University
Mr. Arun Sridharan	Brandeis University
Ms. Dongmei Wu	Mississippi State University
Mr. Zhifan Zhu	Mississippi State University

Subcontractors

Mr. Andrew Jurkevics	Ensemble Systems, Inc.

DISTRIBUTION LIST

Scientific Officer Code 1242
Robert A. Peloquin (3)
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217-5000

Office of Naval Research
800 North Quincy Street
Arlington, VA 22217-5000
- Robert Feden
- Emanuel Fiadeiro
- Lou Goodman
- Tom Kinder
- Rick Spinrad
- Alan Weinstein

Administrative Grants Officer
Office of Naval Research
Resident Representative N66020
Administrative Contracting Officer
Georgia Institute of Technology
206 O'Keefe Building
Atlanta, GA 30332-0490

Defense Technical Info Center (2)
Building 5, Cameron Station
Alexandria, VA 22304-65145

Naval Research Laboratory
Washington, DC 20375-5000
- Code 2627
- Eric Hartwig

Naval Research Laboratory
Stennis Space Center, MS 39529
- John Ellis
- Herb Eppert
- Ed Franchi
- John Harding
- George Heburn
- Harley Hurlburt
- John Kindle
- Paul Martin
- Joe McCaffrey
- William Mosely
- Steve Piacsek

Naval Research Laboratory
Monterey, CA 93943-5006
- Ted Tsui
- Gary Love

Naval Meteorological and Oceanography Command
Building 1020
Stennis Space Center, MS 39529
- Don Durham
- Paul Gaffney

Fleet Numerical Oceanography Center
Monterey, CA 93943
- Mike Clancy
- James Cummings
- Evelyn Hesse
- Robert Plante

Naval Oceanographic Office
Stennis Space Center, MS 39529
- Ted Bennett
- Landry Bernard
- Michael Carron
- Steve Haeger
- Martha Head
- Charles Horton
- Andrew Johnson
- Mike Jugan
- David Martin

Naval Postgraduate School
Monterey, CA 93943
Curt Collins
Robert Haney
Le Ngoc Ly

George L. Mellor
Princeton University
P.O. Box CN710
Princeton, NJ 08544

John Apel
Applied Physics Laboratory
Johns Hopkins University
Laurel, MD 20723

William J. Schmitz
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

Allan R. Robinson
Harvard University
29 Oxford Street, Room 100D
Cambridge, MA 02138

Ron McPherson
National Meteorological Center
5200 Auth Road
Camp Springs, MD 20746

Minerals Management Services
381 Elen Street
Herndon, VA 22070-4817
Bob Labelle
Theresa Paluszkiewz

Malcom Bowman
State University of New York
Stony Brook, NY 11794

University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Christopher Mooers
Dong-Shan Ko

Lakshmi Kantha
University of Colorado
Campus Box 431
Boulder, CO 803009-0431

Rutgers University
P.O. Box 231
New Brunswick, NJ 08903-0231
Scott Glenn
Dale Haidvogel

Texas A&M University
Dept. of Oceanography
College State, TX 77843
David Brooks
Robert Reid

Murray Brown
Minerals Management Services
1201 Elmwood Park Blvd.
New Orleans, LA 70123-2394

MSU Office of Research
Mississippi State, MS 39762
Ralph Powe
Melvin Ray

Arthur Cosby
Director, Social Sciences Research Center
P.O. Box 6343
Mississippi State, MS 39762

Lynne Chronister
Sponsored Program Administration
P.O. Box 6156
Mississippi State, MS 39762

MSU Computer Science Department
Mississippi State, MS 39762
Susan Bridges
Julia Hodges

MSU Engineering Research Center
P.O Drawer 6176
Mississippi State, MS 30762
Joe Thompson
Robert Moorhead

University of Southern Mississippi
Building 1103
Stennis Space Center, MS 39529
Ranjit Passi
Germanna Peggion
Louise Perkins
Robert Willems

John Leese
Department of Meteorology
University of Maryland
College Park, MD 30742

James Lewis
Atlantic Applied Research Corp.
20 S. Seashore Avenue
Long Beach, MS 39560

James J. O'Brien
Florida State University
MS B-174, 012 LOV
Tallahassee, FL 32306-3041

William Schramm
NOAA Center for Ocean Analysis
and Prediction
2560 Garden Road
Monterey, CA 93940

National Center for Atmospheric
Research
P.O. Box 3000
Boulder, CO 80303
Richard Anthes
William Holland
Wayne Shiver
Warren Washington

Ed Harrison
SPAWARS
National Center 1, Room 3E90
Arlington, VA 22203

C. Aaron Lai
Los Alamos National Laboratory
Los Alamos, NM 87545

Houston Advanced Research Center
4800 Research Forest Drive
The Woodlands, TX 77381
Andrew Blanchard
Michael Stanford

Fred Petry
Tulane University
Computer Science Department
301 Stanley Thomas Hall
New Orleans, LA 70118

David Markhan
SPAWARS 165
5 Crystal Park, Room 301
Arlington, VA 22202

Frank Schatzle
Gulf Weather Corporation
Building 1103
Stennis Space Center, MS 39529

Environmental Protection Agency
Building 1103
Stennis Space Center, MS 39529
Eugene Meier
Douglas Lipka

David Powe
NASA Education Programs
Stennis Space Center, MS 39529

R. Dyer
Environmental. Protection Agency
AW-458 Waterside Mall East
Washington, DC 20545

Waterways Experiment Station
Coastal Engineering Research Center
P.O. Box 631
Vicksburg, MS 39180
Martin Miller
Steve Bratos

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. Agency Use Only *(Leave blank).*	2. Report Date.	3. Report Type and Dates Covered.
	30 September 1994	TECHNICAL REPORT

4. Title and Subtitle.
FY93 and FY94 Research Program in Navy Ocean Modeling and Prediction

5. Funding Numbers.
Program Element No.
Project No.
Task No.
Accession No.

6. Author(s).
Lanny A. Yeske
James H. Corbin

7. Performing Organization Name(s) and Address(es).
Mississippi State University
Center for Air Sea Technology (CAST)
Stennis Space Center, MS 39529-6000

8. Performing Organization Report Number.
CAST Technical Report 94-3

9. Sponsoring/Monitoring Agency Name(s) and Address(es).
Office of Naval Research
800 North Quincy Street
Code 1242
Arlington, VA 22217-5000

10. Sponsoring/Monitoring Agency Report Number.
Report 94-3

11. Supplementary Notes.
Research performed under Office of Naval Research Contract/Grant No. N00014-92-J-4109

12a. Distribution/Availability Statement.
Approved for public release; distribution is unlimited

12b. Distribution Code.

13. Abstract *(Maximum 200 words).*

The Mississippi State University Center for Air Sea Technology began operation on 1 October 1992 under a two-year Research Grant (N00014-92-J-4109) issued by the Office of Navy Research. This final technical report is submitted in accordance with requirements contained in the Grant. Included is a discussion of the FY93 (1 October 1992-30 September 1993) research program under the Experimental Center for Mesoscale Ocean Prediction Project with its tasks of Ocean Model Initialization and Evaluation Data; Ocean Model Verification, Evaluation, and Transition; and Scientific Visualization for Model Evaluation. This is followed by the FY94 (1 October 1993-30 September 1994) program which was reorganized into the Coastal and Semi-Enclosed Seas Relocatable Models Project (6.1), the Ocean Model Technology Project (6.2), and the Advanced Development and Transitions Project (6.3). Also included is a discussion of the planned research for FY95 and FY96. This is followed by Appendix I which summarizes eight other contracts obtained by CAST with the Naval Research Laboratory, Naval Oceanographic Office, Army Corps of Engineers Coastal Engineering Research Center, Gulf Weather Corporation, Department of Defense, and Office of Naval Research. Finally, Appendix II summarizes CAST publications completed during this two year period as well as other CAST accomplishments.

14. Subject Terms.
(U) Report (U) Model (U) Navy (U) CAST (U) Ocean (U) Application (U) Evaluation (U) Prediction

15. Number of Pages.
70

16. Price Code.

17. Security Classification of Report.	18. Security Classification of This Page.	19. Security Classification of Abstract.	20. Limitation of Abstract.
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	